

Thacker's School Series.

A TEXT-BOOK OF


INDIAN BOTANY.

W H GREGG



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A

TEXT-BOOK

OF

INDIAN BOTANY

BEING

AN INTRODUCTION TO THE STUDY OF
INDIAN BOTANY.

BY

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P R E F A C E.

WHEN I began teaching Botany in the Hughli College for the B.A. Examination in January 1879, I felt the want of a text-book adapted for Indian students. The plants given as examples in the English, American and German text-books are not procurable in India, and thus render these works unsuitable for Indian requirements.

These pages are the result of my leisure hours for four years. Almost everything in this volume is deduced from my own personal experiences.

The brevity required in an introductory treatise will be my excuse if I omit the details necessary for a more accurate knowledge. It would be impossible, even were it desirable, to define, in an elementary work of this kind, every scientific term in use by every writer.

As the object of a study of natural science is the cultivation of the observant faculties in the relation to the phenomena of nature, the specimens for examination, both by the naked eye and by the aid of a microscope, must be readily procurable, otherwise the interest and benefit of the study is lost. From an educational point of view, the value of an acquaintance with natural science lies not so much in the mere accumulation of facts as in familiarity with the methods of scientific investigation. The man who has been well trained in physical science has so great an intellectual advantage over the man who has not been thus trained, that, other things being equal, he will be able to form a sounder judgment, not only on scientific questions, but on things in general.

Sir J. D. Hooker has stated, that "the pupil may well afford to forget all the Botany he has learned, provided only that he retains those habits which it inculcates, of observing accurately, reasoning intelligently, and describing what he has seen more methodically, accurately, and concisely than he would otherwise have done."

Professor Huxley, in an address delivered at Birmingham on 1st October 1880, said, that "the distinctive character of our own times lies in the vast and constantly increasing part which is played by Natural Knowledge. Not only is our daily life shaped by it—not only does the prosperity of millions of men depend upon it, but our whole theory of life has long been influenced, consciously or unconsciously, by the general conceptions of the universe, which have been forced upon us by physical science.

"In fact, the most elementary acquaintance with the results of scientific investigation shows us that they offer a broad and striking contradiction to the opinion so implicitly credited and taught in the middle ages.

"The notions of the beginning and the end of the world entertained by our forefathers are no longer credible. It is very certain that the earth is not the chief body in the material universe, and that the world is not subordinated to man's use. It is even more certain that nature is the expression of a definite order with which nothing interferes, and that the chief business of mankind is to learn that order and govern themselves accordingly. Moreover this scientific 'criticism of life' presents itself to us with different credentials from any other. It appeals not to authority, nor to what anybody may have thought or said, but to nature. It admits that all our interpretations of natural fact are more or less imperfect and symbolic, and bids the learner seek for truth not among words but among things. It warns us that the assertion which outstrips evidence is not only a blunder but a crime."

With reference to the phrase 'applied science,' he stated,—"I often wish it had never been invented, for it suggests that there is a sort of scientific knowledge of direct practical use, which can be studied apart from another sort of scientific knowledge, which is of no practical utility, and which is termed 'pure science.' But there is no more complete fallacy than this. What people call 'applied science' is nothing but the application of pure science to particular classes of problems. It consists of deductions from those general principles, established by reasoning and observation, which constitute pure science. No one can safely make these deductions until he has a firm grasp of

the principles; and he can obtain that grasp only by personal experience of the processes of observation and of reasoning on which they are founded."

The practical benefit derived from the study of the abnormal vital phenomena of plants has, of late years, received a good deal of attention. Sir James Paget recently counselled human pathologists to study the diseases of plants. There, he said, you will be able to study elemental pathology—the pathology of cells and tissues freed from the complexity of a circulating blood and a nervous system.

The greater part of the student's knowledge must always be gained in the field, or with the dissecting knife in hand. Still he will need to be guided by the experience of previous observers, and to be acquainted with the recognised descriptive terms used in his science. It is for these purposes, and not to replace the necessity for observations of his own, that I have introduced the tables given at pages 5, 7, 13, 15, 17, 19, 31, 40, 43, 46, 50, 53, 65, and 67. These tables will also be found useful in describing plants (see p. 71).

With reference to the naming of plants found during excursions (see pp. 286—293). The following works are essential for reference. With regard to flowering plants, consult Roxburgh's *Flora Indica*, Mr. C. B. Clarke's Edition. *Flora of British India*, Hooper: "This new work might be supposed to supersede Roxburgh altogether, but I do not think that non-professional Botanists can use a book containing 15,000 species, unless they have many landmarks, both of orders and genera, well fixed in their minds. To search a book of this size for a plant is worse than searching for a needle in a bundle of hay. Now, Roxburgh's book, it has been found by experience, is a useful book for planters and other English denizens who, without being great Botanists, take a sufficient interest in the plants to spend a little time in really working with a book."—Clarke. For the naming of cultivated plants, a manual of gardening by Mr. T. A. C. Firminger will be found useful.

For the purpose of naming non-flowering plants (Ferns), the *Synopsis Filicum* of Hooker and Baker should be consulted (see pp. 232 and 236). For the naming of Mosses and Liverworts, refer to books mentioned at pp. 246 and 247. No plants are so easy to prepare for the herbarium

as mosses ; they easily part with any moisture which they have imbibed ; and if common eare is used, they are not liable to be spoiled by damp or seriously injured by the depredation of insects.

With regard to the Thallophyta, the English Edition of Saeh's text-book (Clarendon Press) should be eonsulted ; also works named on pages 263, 273, and 281.

The tables given at pages 80*g*, 80*k*, 187, 229, 246, 256, and 278 will be found useful by beginners to enable them to get a general idea of the position occupied by the various groups of plants in the vegetable kingdom.

The whole of the present work has been earefully revised by Mr. W. Botting Hemsley, of Kew.

"At the meeting of the British Association at Swansea in August 1879, a new classification of Cryptogams was proposed by Mr. Alfred W. Bennett. He retains Saeh's class of Protophyta for the lowest forms of vegetative life : but restores the primary division of the remainder of Thallophytes into Fungi and Algæ, as being more eonvenient to the student, and at least as much in aeoordanee with probable genetie affinities.

"As regards minor points, the Characeæ are removed altogether from Thallophytes, and again constituted into a separate group of the first rank ; Myxomycetes are regarded as presenting a low type of structure, scarcely raised above the Protophyta, and not exhibiting true sexual conjugation ; Volvox and its allies are removed from the Zygosporæ to the Oosporæ ; and the Phæosporæ are separated off as a distinct order from the Fucaeæ.

"The Thallophytes are, therefore, first of all divided into three primary classes : Protophyta, Fungi, and Algæ. The Protophyta are divisible into two sub-classes, Protomycetes and Protophyceæ. The Protomycetes consist of a single order, the Schizomyces, of which Saceharomyces is regarded as an aberrant form. The Protophyceæ are composed of the Protocoecææ (including Palmellææ and Scytonemææ), Nostoeææ, Oscillatoricæ, and Rivulariæ. The Myxomycetes are treated as a supplement to the Protophyta.

"The Fungi are made up of three sub-classes, employing in the main the same eharacters as Sach's, but in their terminology, using the syllable 'spern' instead of 'spore.'

The first division, the Zygomycetes (or Zygospermeæ Achlorophyllaceæ), is composed of the Mucorini only (including the Piptocephalidæ). The second, the Oomycetes (or Oospermeæ Achlorophyllaceæ), comprises the Peronosporæ and Saprolegniæ (including the Chytridiaceæ). The third, the Carpomycetes (or Carpospermeæ Achlorophyllaceæ), is made up of the Uredinæ, Ustilagineæ Basidiomycetes, and Ascomycetes, the lichenes being included in the last as a sub-order.

“The Algæ are arranged under three corresponding subclasses. The Zygomycetæ (or Zygospermeæ Chlorophyllaceæ) is made up of the following orders:—Pandorinæ, Hydrodictyæ, Confervaceæ (under which the Pithophoraceæ may possibly come), Ulotrichaceæ, Ulvaceæ, Botrydiæ, and Conjugatæ (the last comprising the Desmidiæ, Diatomaceæ, Zygnemaceæ, and Mesocarpeæ). The Oophyceæ (or Oospermeæ Chlorophyllaceæ) includes the Volvocinæ, Siphonæ (with the nearly allied Dasycladæ), Sphæropleaceæ (Edogoniaceæ), Fucaceæ, and Phæosporæ. The Carpophyceæ (or Carpospermeæ Chlorophyllaceæ) is made up of the Coleochætææ and Floridææ.

“The Characeæ constitute by themselves a group of primary importance; the Muscinæ are unchanged, comprising the Hepaticæ and Musci (including Sphagnaceæ).

“In vascular Cryptogam it is proposed to revert to the primary distinction into Isosporia and Heterosporia as most in accordance with probable genetic affinities. The Isosporia consist of the Filices (including Ophioglossaceæ), Lycopodiaceæ, and Equisetaceæ. The Heterosporia comprise the Rhizocarpeæ and Selaginellaceæ. In the terminology of the Heterosporia, the inconvenience and incorrectness are pointed out of the use of the terms ‘Macrospore’ and ‘Macrosporangium;’ and it is proposed to call the two kinds of spores, and their receptacles respectively, Microspore, Megaspore, Microsporangium, and Megasporangium; or better, in reference to their sexual differentiation, Androspore, Gynospore, Androsporangium, and Gynosporangium.”

W. H. G.

CHINSURAH;

November, 1882.

CONTENTS.

CHAPTER I.

PAGE.

THE EXTERNAL FORM OF PLANTS	1
THE ROOT	3
THE STEM	7
BRANCHING	14
THE BUD	15
LEAVES	18
FORMS OF FOLIAGE LEAVES	23
HAIRS	33
THE FLOWER	34
THE INFLORESCENCE	37
THE CALYX	41
THE COROLLA	44
THE PERIANTH	47
THE ANDRŒCIUM	48
THE GYNŒCEUM	51
THE FRUIT	56
THE SEED	68
DESCRIPTION OF PLANTS	71
THE FLORAL DIAGRAM	76

CHAPTER II.

CLASSIFICATION AND SPECIAL MORPHOLOGY	77
NOMENCLATURE	78
SYSTEMS OF CLASSIFICATION	79
THE LINNÆAN SYSTEM	80
THE NATURAL SYSTEM	80 <i>g</i>
DICOTYLEDONS { General Remarks	80 <i>h</i>
{ Abstract of Orders	80 <i>l</i>
{ Details of Orders	87
MONOCOTYLEDONS { General Remarks	183
{ Abstract of Orders	187
{ Details of Orders	190
GYMNOSPERMIA	221
CRYPTOGAMIA { Vascular Cryptogams { General Remarks	225
{ Vascular Cryptogams { Abstract of Orders	229
{ Vascular Cryptogams { Details of Orders	235
{ Muscinæ	247
{ Muscinæ	249
{ ThallopHYta	255
{ ThallopHYta	256
{ Detail of Orders	263
DIRECTIONS FOR COLLECTING BOTANICAL SPECIMENS	286

INDEX	295
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ERRATA.

Page 104, line 5 from bottom, *for* 'black and green tea.' etc., *read* 'The indigenous or hybrid plant makes the best black tea. and the plant produced from seed originally imported from China, the best green tea.'

Page 179, line 1, *for* 'Ramex,' *read* 'Rumex.'

A TEXT-BOOK OF INDIAN BOTANY.



CHAPTER I.

The External Form of Plants.

ANIMATED nature is divided by naturalists into two kingdoms—*animal* and *vegetable*, easily distinguished from each other in their more highly developed forms, but passing insensibly into each other in their simple ones. In a botanical sense, the largest trees and the microscopic 1-celled fungi and algæ (see Fig. 92cc, page 80d) are alike *plants*. The essential difference between plants and animals is in their mode of nutrition. Most plants feed upon inorganic matter, which they absorb in a liquid or gaseous state; whilst animals feed upon organic matter formed by the vital processes of animals and plants. Consequently, plants have no complex digestive organs; and their classification is based mainly upon their mode of reproduction, and upon the infinite variety of modifications exhibited by their reproductive and the hitherto subsidiary organs.

The study of botany is best commenced with the careful observation of the different parts of living plants, their

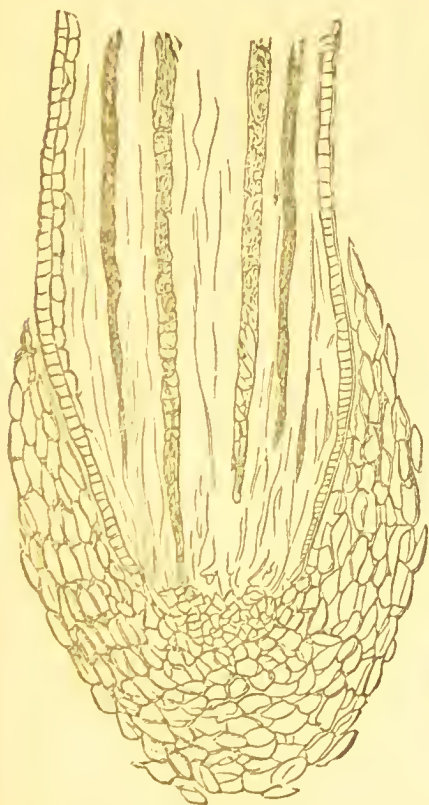
positions and arrangement in reference to one another, the order in which they make their appearance, and their uses to the plant itself. Every portion of a plant which has a distinct function to perform in the phenomena of vegetable life, is called an *Organ*. "The term *Member* is used when we speak of a part of a whole, in reference to its form or position, and not to any special purpose it may serve. In the same manner, from a morphological point of view, the stems, leaves, hairs, and roots are simply members of the plant-form; but a *particular* leaf, a *particular* portion of the stem, etc., may be an organ for this or that function, which it is the province of physiology to investigate."

All the members of the most perfect plants, such as mangoes, palms, ferns, and mosses, etc., may be referred to a few original forms: 1st, the *axes* (caulionics), comprising the root and stem, which is the central part or column of a plant, around which the other parts are disposed. 2nd, the *foliage leaves* (phyllomes), termed in popular language simply leaves, the organs of assimilation, and the *transformed or metamorphosed leaves*, which are also recognized as leaf-like, including the thick scales of bulbs, the cuticular appendages of many tubers, the parts of the calyx and corolla, the stamens and carpels, many tendrils and prickles, etc. 3rd, the *hairs* (trichomes), including root-hairs, glandular hairs, etc., the distinguishing character of which is, that they all originate as outgrowths of epidermal cells. In these plants the process of development, that is, the gradual advancement of growth, through a series of progressive changes, has given rise to the production of a diversity of parts (*differentiation*); hence the term *Cormophyta* has been given to them. In algæ and fungi, roots, in a morphological sense, are always absent, and the idea of the leaf, as understood in the higher plants, can no longer be rightly applied; for these vegetable structures the term *Thallophyta* is used, the thallus performing the function of axes and leaves. Although in general the distinction between cormophyta and thallophyta is easily recognized, certain groups or both sides possess so close an affinity to each other, that no sharp boundary can be drawn between them.

The Root.

The term Root is applied in botanical morphology (in contrast to its use in popular language) only to such outgrowths of the substance of the plant as are clothed at their growing apices with a layer of tissue, the *rootcap* (see Fig. 1). This cap is well seen in the aërial roots of *Ficus Indica* (Bat), which are of a pinkish white colour; the rootcap is the dark brown portion at the apex; it is also well seen in the aquatic roots of *Lemna*. Roots occur only in those plants the tissue of which is penetrated

Fig. 1.



Longitudinal section through the apex of a root shewing the rootcap, fundamental tissue, fibro-vascular bundles, and epidermal tissue magnified (after Thomé).

Fig. 2.



Seed of *Lab-lab vulgare* germinating, shewing the radicle or primary root.

Fig. 3.



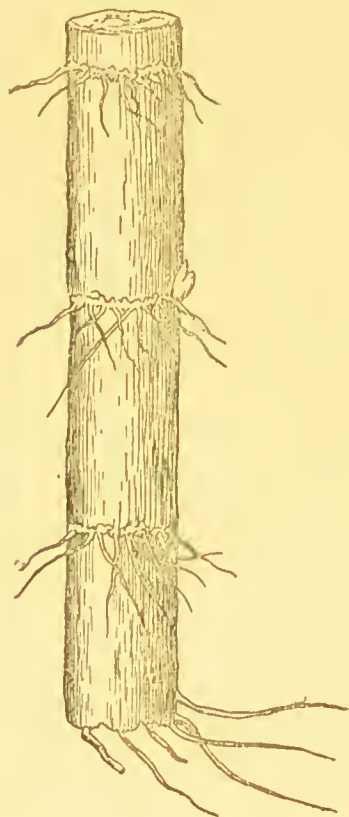
Cotyledons, plumule, and radicle of *Lab-lab vulgare*.

by fibro-vascular bundles; and they themselves therefore always contain fibro-vascular bundles. A root is usually formed even in the young embryo which proceeds from the fertilized ovule, and is generally termed the *Primary Root* (see Figs. 2 and 3). In many dicotyledons the primary roots continue to grow vigorously; in monocotyledons and cryptogams, they are weakly and soon die. Besides the primary roots, there are usually

formed in addition a large number of *secondary roots*: when

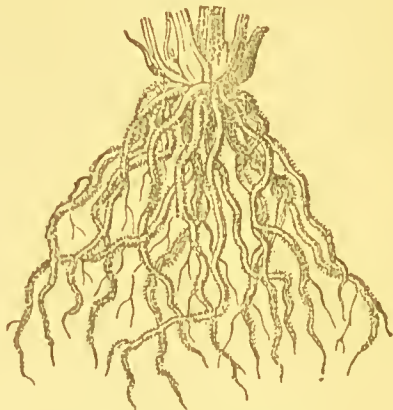
the stem possesses clearly developed nodes and internodes, these roots commonly proceed from the former (see Figs. 4 and 5). Occasionally roots may arise in abnormal positions from stems, leaf-stalks, and leaves: these are termed *adventitious roots* (see Fig. 6).

Fig. 4.



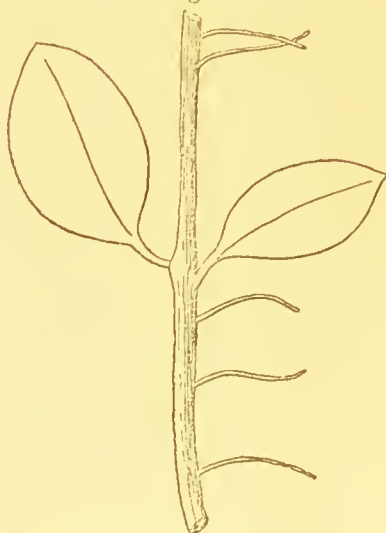
Cutting of Sugar-cane shewing the secondary roots developed from the nodes.

Fig. 5.



Fibrous secondary roots of *Cynodon dactylon*.

Fig. 6.



Adventitious roots of *Hoya*.

When the radicle or primary root lengthens and dilates it is termed a *tap-root*, as in most dicotyledons (see Fig. 7). A *fusiform* root is a thickened tap-root, tapering towards the apex, the lateral branches being only

slightly developed, as in *Daucus carota* (Gájar) (see Fig. 8). A *napiform* root is a tap-root, in which the upper portion is very largely developed, as in *Beta vulgaris* (see Fig. 9).

Fig. 8.



Fig. 9.

Napiform root of *Beta vulgaris*.

Fig. 7.



Tap-root as in many dicotyledons.

Fig. 10.

Fibrous and tuberous roots of *Asparagus*.Fusiform root of *Daucus carota*.

Secondary roots, which are filiform (thread-like), as in grasses, are termed *fibrous*. Fibrous and tuberous secondary roots occur in *Asparagus* (see Fig. 10).

The following abstract shews clearly the different forms of roots:—

Roots	{	Primary Roots	{ Tap Root: Ex., Many Dicotyledons.
			{ Fusiform Root: Ex., Carrot.
			{ Napiform Root: Ex., Beet.
	{	Secondary Roots	{ Fibrous Root: Ex., Grass.
			{ Fibrous and Tuberous Roots: Ex., <i>Asparagus</i> .
	{	Adventitious Roots	Ex., Banyan and Bryophyllum.

Roots growing free in the water, as in *Lemna* and *Pistia*, are termed *aquatic* (see Fig. 11). In *Ficus Indica*, roots are given off by the branches, which for a time grow free in the air: these are termed *aërial*. In some orchids, as in *Vanda Roxburghii*, the aërial roots remain unconnected with the soil, fixing the plant on the branches of the tree on which it grows, and drawing nourishment from the air and the decaying organic matter that accumulates in the crevices of the bark: such roots are called *epiphytic*. In *Loranthus* (Mandá), &c., the roots penetrate the surface of the plant on which they grow and become organically adherent to its tissues so as to derive nourishment from it; these roots are termed *parasitic* (see Fig. 12). Roots rarely form chlorophyll (the source of the green colour of plants); usually they are quite colourless, not only when they grow in the ground, but also in water or in air.

Fig. 11.

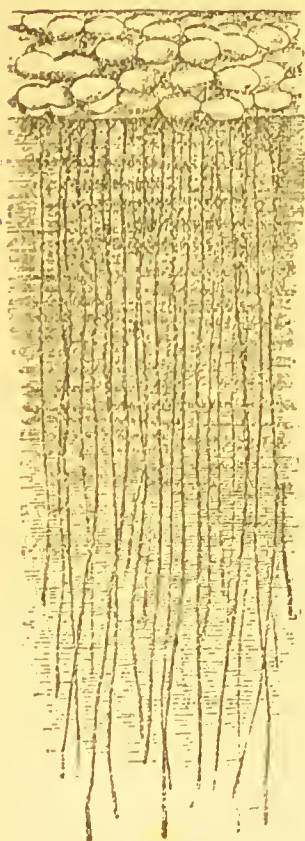
Aquatic roots of
Lemna.

Fig. 12.

Parasitic roots of *Loranthus longiflorus*, growing
on a branch of *Morus alba* (Tút).

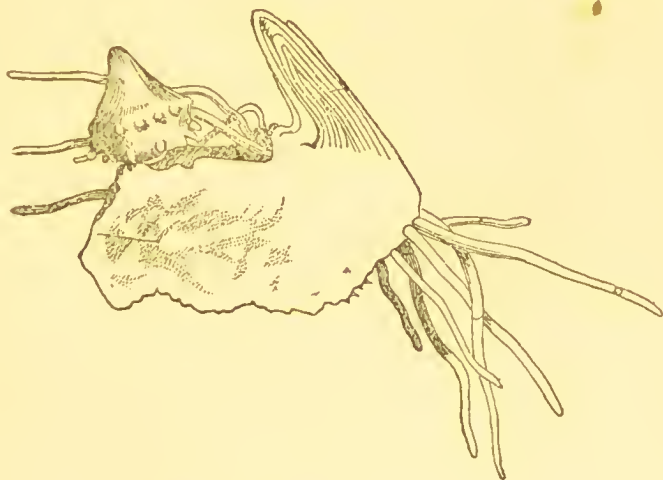
Abstract of roots arranged according to the substance from which they draw their nourishment:—

Roots	{	Terrestrial Roots: Ex., Mangoes, Palms, etc.
		Aquatic Roots: Ex., Pistia.
		Aërial Roots: Ex., Banyan.
		Epiphytic Roots: Ex., Orchids.
		Parasitic Roots: Ex., Loranthus.

The Stem.

The stem is usually the ascending portion of the axis, and includes all those parts of a plant morphologically equivalent in bearing leaves. Structurally, it differs from a root in having no development of cells forming a cap over the growing apex. When the stem is thickened and remains underground, as in some *Aroideæ* (Kachú), it is termed a *Corm* (see Fig. 13).

Fig. 13.



Section of a *Corm*.

It is of very common occurrence with Cryptogams and Angiosperms for the axes to continue to grow underground, and to send up at intervals long foliage leaves or shoots. When such axes lie horizontally or obliquely on the ground and produce lateral shoots, they are called *rhizomes*, examples of which are to be found in *Zingiberaceæ* (Adá, Haldí), *Marantaceæ* (Pátí), *Nymphaeaceæ*

(Shálúk), *Ferns*, &c. Rhizomes can be distinguished from roots by possessing leaf-scales; they resemble a number of corns, and while growing at one end, slowly die away at the other. *Tubers* (see Fig. 14) and *bulbs* (see Figs. 15 & 16) are also stem structures; the former are characterized by the preponderance of the axial mass with a very small amount of leaves; the latter, on the contrary, by the preponderance of leaves closely united round a short stem. The bulb is termed *scaly* or *squamose* when the leaf-scales only partially overlap, as in *Lilium*, *Oxalis*, &c. (see Fig. 15),

Fig. 15.

Fig. 14.

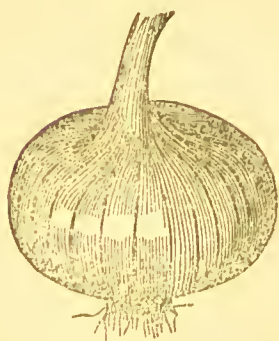


Tuber of a Potato,
shewing the rudimen-
tary buds (eyes).



Scaly bulb of Lily.

Fig. 16.



Tunicated bulb of Onion.

or *tunicated*, when the scales form complete sheaths to the bulb, as in the Onion (*Peyaj*) (see Fig. 16).

Stems developed above ground are *woody*, as in the mango and palm; *succulent*, as in *Opuntia* (*Nágphíná*); *herbaceous*, as in *Labiata* (*Tulsi*), where they remain green, and do not become woody. A woody stem, when branched, as in the mango, is sometimes called a *trunk*; when unbranched as in

the palm, a *caudex*. *Runners* are stems producing buds and secondary roots like a rhizome, as in *Pistia* (Tákápáná) (see Fig. 17); the independent plant thus formed is called an *off-set* or *stolon*.

Fig. 17.



Plants of *Pistia*; the smaller one to the right is of later growth, and is connected with the parent plant by a runner.

Stems are usually round (see Fig. 18); they are, however, sometimes square, as in *Labiata*; in *Cereus hexagonus* the stems are six-sided; in *Cyperaceæ* (*Mútha*) they are triangular (see Fig. 18). Most stems are solid, but in the majority of *Gramineæ*, *Cucurbitaceæ*, in *Umbelliferae*

Fig. 18.



Portions of triangular, ribbed, and square stems.

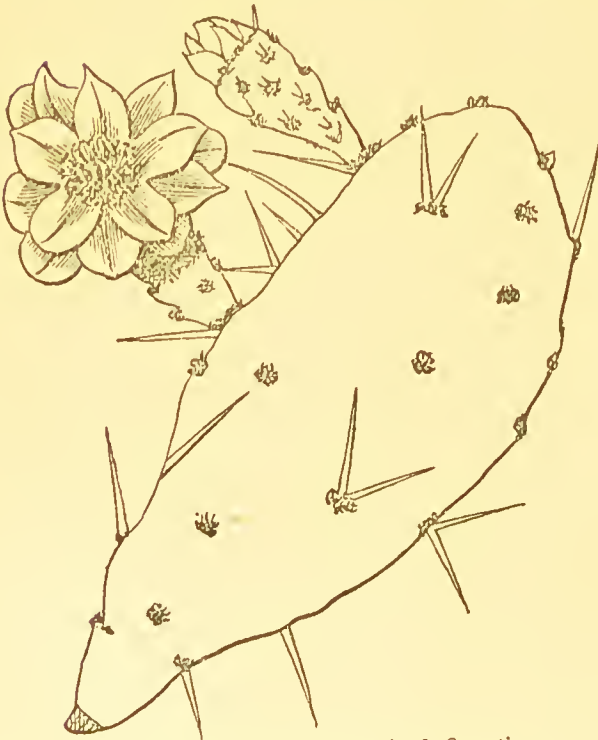
(Gájar), and *Equisetaceæ*, &c., they are hollow. Leaf-like shoots (*cladodes*) are found in those phanerogams in which large green foliage leaves are wanting, and replace them physiologically; their axial structure is of considerable superficial extent, and they produce and expose to the light large quantities of chlorophyll; they generally only bear very small membranous scale-leaves. *Opuntia* (see Fig. 20), *Coccoloba* (see Fig. 21), and *Xylophylla*, furnish good examples of cladodes.

Fig. 19.



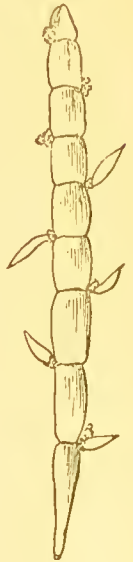
Creeping triangular stem of *Carex*.

Fig. 20.



Flattened stem (cladode) of *Opuntia*.

Fig. 21.



Flattened stem of *Cocoloba platyclada*.

Axes which have the power of climbing are termed *twining* or *climbing stems*. This twining is a consequence of unequal growth. Only a few plants twine to the right (*Dextrorse*, i. e., from right to left as

Fig. 23.

Fig. 22.



Climbing stem of *Dioscoreæ*, twining to the right.



Climbing stem of *Convolvulus*, twining to the left.

one looks at the support round which the plant twines), following the course of the sun or of the hands of a watch: among these are some *Dioscoreæ* (see Fig. 22); the greater number twine to the left (*Sinistorse*), as *Convolvulaceæ* (see Fig. 23), &c. Some plants are endowed with irritable organs (*tendrils*) which, when they touch any object, clasp it; these organs are

sometimes metamorphosed leaves (*leaf-tendrils*), as in *Gloriosa* and various leguminous plants (see Fig. 24). Examples of *stem-tendrils* are to be met with in *Vitaceæ*, *Passifloraceæ*, &c. Stems also have the power of climbing by *hooks*, as some Palms, Brambles, *Bougainvillea*, *Spectabilis*, *Artabotrys odoratissimus*. Other plants climb by means of *adventitious roots*, as some orchids, *Hoya*, *Ficus Scandens*, &c.

The following abstract clearly shews Darwin's classification of climbing stems:

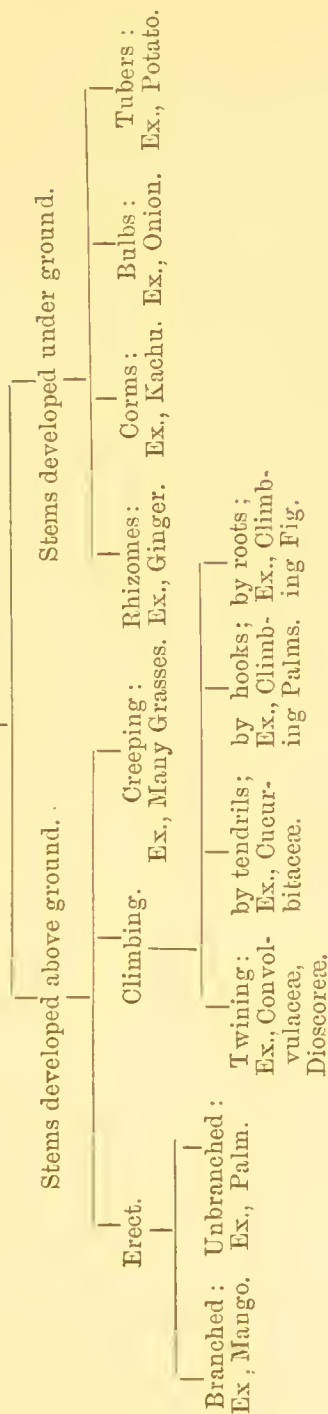
- Climbing Stems. {
1. Stems that twine spirally in a *dextrorse* or *sinistorse* manner. Example: *Convolvulus* and *Dioscorea*.
 2. Stems that twine by means of tendrils. Example: Pea, *Cucurbitaceæ*.
 3. Stems climbing by means of hooks. Example: Climbing Palms.
 4. Stems climbing by means of adventitious roots. Example: Climbing Fig, Ivy.

Fig. 24.



Compound leaf of a Pea, in which the 7 terminal leaflets are metamorphosed into tendrils.

FORMS OF STEMS.



Branching.

“The different members of a plant spring out of one another; the members produced may be similar or dissimilar to the member which produces them. In the former case the formation of new members is ordinarily termed *Branching*.”

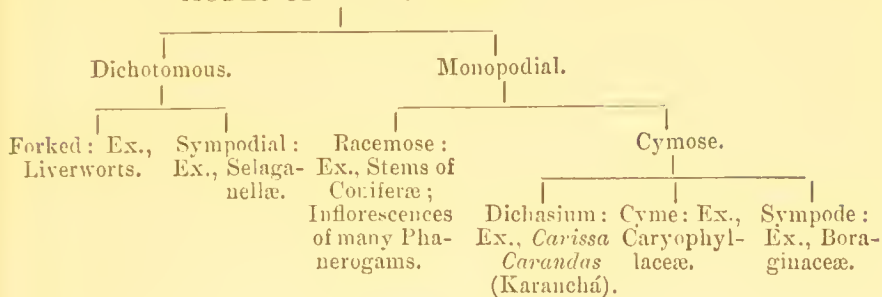
There are two principal forms of branching, *viz.* : first, *Dichotomous*; and second, *Monopodial*.

Dichotomy is caused by the cessation of the previous increase in length of a member at the apex, and by two new apices arising at the apical surface close to one another, which develop in diverging directions. *Dichotomous* branching is very common among *Thallophyta*, especially *Algæ* and the lower *Hepaticæ*; it rarely occurs among *Phanerogams*. “In *Monopodial* branching the new members originate by lateral budding; the generating structure following the direction of its previous axis of growth continues to grow at its apex, while lateral structures are given off beneath it.” This is the usual mode of branching in most *Phanerogams*. The development of *Dichotomous* branching may take place either in a forked or in a sympodial manner; forked, when at each bifurcation the two branches develop with equal strength; sympodially, when at each bifurcation the one branch develops more strongly than the other.

An original *Monopodial* branch system may develop in a *racemose* or in a *cymose* manner. In the *racemose* system the primary shoot continues to develop more strongly than all the lateral shoots; in the *cymose* development the lateral shoots are the strongest. Of this last form of development, there are three kinds: (a) the *dichasium*, when two or more lateral shoots develop more strongly than the primary shoot which soon dies (this may be termed false dichotomy); (b) the true *cyme*; and (c) the *sympode*, which occurs when one lateral shoot develops with greater vigour than the portion of the primary shoot which lies above its origin. The following abstract with examples will make

the matter more clear (after *Sachs*) :—

MODES OF BRANCHING.



The Bud.

The bud is a compound structure, composed of the growing end of the shoot surrounded by a number of rudimentary leaves. The leaves being formed quickly, one after another, envelope and overarch the end of the growing shoot, and thus form a bud. It is only when perfectly developed that the leaves turn outwards from their position in the bud. The growing apex represents the future stem with the intervals (*internodes*) between the points of origin of the leaves as yet undeveloped. If these intervals undergo a considerable and often very great extension, the leaves, when escaping from their position in the bud, become placed at a distance from one another, and the result is, a stem with extended internodes. As respects the position of the bud, it is *terminal* when it is situated at the end of a branch; *axillary* when it grows in the axil of a leaf (*i. e.*, in the angle which its upper surface makes with the stem), or *adventitious* when it springs from any other part of a stem except these two. The latter kind occurs but rarely; and only in plants in a very active state of vitality, as on detached leaves of *Bryophyllum* and some *Begonias*, &c. Gardeners take advantage of this curious phenomenon in propagating these plants.

Shoots which become detached from the mother-plant in a but slightly developed condition, and then continue to grow by independent nourishment, while they repeat the peculiarities of the primary shoot, are called *Gemmæ*

or *Bulbils*; the propagation by gemmæ is very common in the *Liverworts*; bulbils frequently occur in the *Dioscoreæ* (see Fig. 25), *Liliaceæ*, etc.

Fig. 25.



Portion of stem of a *Dioscoreæ*, with a bulbil at the axis of the leaf.

The relative position of the bud-scales, foliage leaves, sepals, and petals in the bud may be termed their *æstivation*, and is usually *imbricate* when the margins of contiguous leaves overlap one another; less frequently it is *valvate*, as in the calyx of *Malvaceæ*, when they merely touch one another by their edges. The principal forms of imbricated æstivation are the *veillary* peculiar to the

Papilionaceæ, when one leaf much larger than the rest encloses the others; *equitant*, when each leaf sharply folded embraces its successor, as in the *Gramineæ* (Fig. 26); *obvolute*, or *half equitant*, when each succeeding leaf embraces only one-half of the blade of its successor; and *quincun-*
cial, as in the calyx of the rose, when two leaves are covered, two uncovered, and the fifth so placed that one of its margins overlaps one of the covered leaves and the other is overlapped by one of the outer leaves.



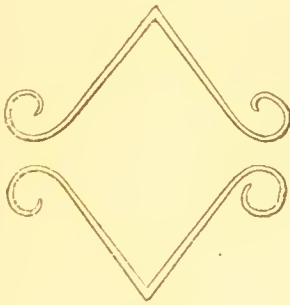
Equitant æstivation of a grass.

By *vernation* is meant the position occupied by the separate leaves in the bud. The principal forms are the *conduplicate*, when the leaf is folded perpendicularly at the mid-rib, as in the *Gramineæ* and *Sapotaceæ*; and *involute* when both margins are rolled inwards, towards the mid-rib, as in *Artoocarpus* (Kántál), *Nelumbium*, and *Quisqualis*. When both mar-

gins are rolled outwards, towards the mid-rib, the vernation is termed *revolute*, as in *Nerium* (Karabí) (see Fig. 27)

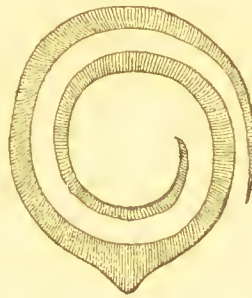
and *Polygonaceæ* (Marich); in *Palmeæ* (Supári, Tál, &c.), where the blade is folded, as in a fan, it is termed *plicate*; *convolute*, when the leaf is rolled up from side to side, with only one edge free, as in the plantain (see Fig. 28); *circinate*, where the apex of the leaf is rolled down towards the base, as in the ferns. The terms *æstivation* and *vernation* are occasionally used in a somewhat different sense to that given above, æstivation (prefloration) being the term used for the arrangement of the floral members in the flower-bud before the expansion of the flower; and vernation (prefoliation) being used to denote the arrangement of the foliage leaves in the leaf-bud before its expansion, including the mode of folding of separate leaves, and their relative position to one another.

Fig. 27.



Revolute vernation
of *Nerium*.

Fig. 28.



Convolute vernation
of the Plantain.

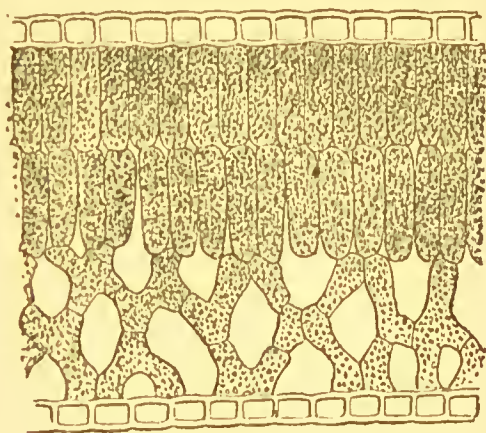
Abstract of the arrangement of leaves in the bud:—

Arrangement of leaves in the bud.	{	Æstivation	{	Imbricate	{ Vexillary: Ex., Papilionaceæ.								
					{ Equitant: Ex., Grasses.								
					{ Obvolute.								
					{ Quineuncial: Ex., Calyx of the Rose.								
	{	Vernation	...	{	Valvate ...	Ex., Calyx of Hibiscus.							
						{	Conduplicate: Ex., Sapota.						
								{	Involute: Ex., Nephelium.				
										{	Revolute: Ex., Nerium.		
												{	Plicate: Ex., Many Palms.
{	Circinnate: Ex., Ferns.												

Leaves.

Leaves are the lateral structures issuing from the stem and its branches below their growing points. "Foliage leaves are always distinguished by their green colour owing to their containing abundance of chlorophyll. It is these which in popular language are exclusively called leaves. From the point of view of the theory of descent we are justified in considering all other forms of leaves as subsequent metamorphoses of foliage leaves. These latter are, therefore, regarded as the original typical leaves." The term *Phyllome* is used in a comprehensive sense to signify any leaf, or modification of a leaf, springing from the axis; it always originates from the growing cellular tissue; never

Fig. 29.



Sections through the cellular tissue of a leaf, shewing the different kinds of cells and inter-cellular spaces in the lower part of the leaf (magnified).

from those parts of the stem which already consist of fully differentiated tissues. Leaves have their origin from the external tissue of the stem, never from the internal tissues, as is the case in roots and branches. Usually, leaves are formed of several layers (see Fig. 29), and the layers may then be distinguished into epidermal tissue, fundamental tissue, and fibro-vascular bundles; the system of the fibro-vascular bundles running into the leaf, forms the so-called *vernation*; there is usually a *mid-rib* which runs from the base to the apex of the lamina, and divides it more or less symmetrically into two similar halves.

According to the functions and positions of leaves, they may be classified into four kinds: *First*, *Seed, leaves*, or *cotyledons*, formed within the seed; they are sometimes thin

and resemble foliage leaves, as in Convolvulacæ; sometimes they are thick and fleshy, as in Leguminosæ and Cucur-

Fig. 30.



bitaceæ. *Second, Covering leaves:* In this class are included *bud-scales*, as in *Ficus Indica*, &c., *bracts*, the leaves of the inflorescence, or flower region of the stem (these are mostly smaller than the foliage leaves), the *glumes* that enclose the flowers of *Gramineæ*, the *paleæ* interspersed with the flowers in many *Compositæ*, and *spathes* in *Aroidæ* (see Fig. 30); sometimes the bracts are coloured, as in *Bougainvillea*, *Poinsettia*, &c. The scales on the rhizomes of *Zingiberaceæ*, *Marantaceæ*, &c., belong to this class. *Third, Foliage leaves;* and *fourth, Floral leaves*, including *sepals*, *petals*, *stamens*, and *carpels*; these will be more fully described under the section flower.

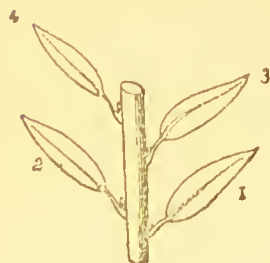
Inflorescence of *Aroideæ* surrounded by a spathe.

Abstract shewing the classification of leaves, according to their functions and positions:—

	Cotyledons.				
	Covering leaves	...	{ Bud Scales:	Ex., Ficus.	
			{ Bracts:	Ex., Acanthaceæ.	
			{ Glumes:	Ex., Grasses.	
			{ Paleæ:	Ex., Many Compositæ.	
			{ Spathes:	Ex., Aroidæ.	
	Foliage leaf	...	{ Scales:	Ex., Rhizomes.	
			(See abstract, p. 31)		
	Floral leaves	...	{ Sepaloid.		
			{ Petaloid.		
			{ Staminate.		
			{ Carpellary.		
Leaves	...				

The arrangement of the leaves on the axis is termed *Phyllotaxis*. An axial structure may produce the lateral members which are equivalent to one another, so that either only one arises at the same level or several; in the first case the members formed in succession are termed *solitary* (see Fig. 31); in the second case all the similar lateral members arising at one level form a *whorl* or *verticil*, as in the foliage leaves of *Nerium* (see Fig. 40), and in the sepals and petals, &c., of many flowers. When alternating whorls have only two members, the position of the members is said to *decussate*—a very common occurrence with foliage leaves (see Fig. 32).

Fig. 31.



Solitary leaves.

Fig. 32.

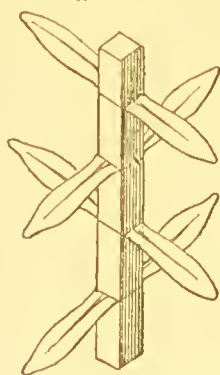


Diagram shewing the arrangement of decussate leaves.

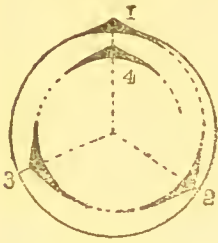
Among the different arbitrary constructions which may be attempted on paper, for the purpose of comparing the relative positions of the members of an axis, or of reducing them to short geometrical or arithmetical expressions, the following is of peculiar interest, and has been specially employed to

denote the relative positions of the leaves and lateral shoots of the stem. For example, select a shoot of *Ficus religiosa* and draw a string round the stem so as to pass from leaf to leaf; it will be seen that the sixth leaf is placed above the first, and the string has passed twice completely round the stem. The series of leaves included by the spiral line is called a *cycle*; and the fraction of the circumference of the stem between any two succeeding leaves, the *angular divergence*. In this case, the angular divergence is $\frac{2}{3}$; the number of leaves in the circle being placed as the denominator of the fraction, and the number of circles round the stem included in the cycle as the numerator.

The simple forms of arrangement are the most common.

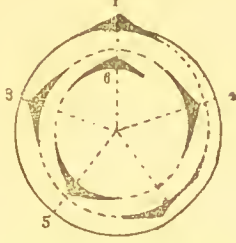
In the *Gramineæ* the plan is $\frac{1}{2}$, the third leaf being placed

Fig. 33.



Horizontal projection of a cycle of the $\frac{1}{3}$ arrangement.

Fig. 34.



Horizontal projection of a cycle of the $\frac{2}{5}$ arrangement.

directly above the first; in *Cyperaceæ*, it is $\frac{1}{3}$; in *Ficus religiosa*, $\frac{2}{5}$; in *Linum usitatissimum* (Tisi), $\frac{3}{8}$; in the buds of potato-tuber, $\frac{5}{13}$, and so on. It will be observed that each fraction has its numerator com-

posed of the sum of the numerators of the two preceding fractions, and its denominator of the sum of the two preceding denominators. The angle of divergence frequently becomes changed from the more rapid growth in thickness of the axial structure on one side than on the other; and still more commonly by torsion around its own axis of growth. A transverse section of the bud, however, enables the observer to examine the true divergence of the leaves.

The place whence a leaf springs from the stem is called its *insertion*. Leaves are either articulated there, as in most Dicotyledons, separating by a distinct line of fracture when mature, or they merely wither down, and leave their bases as a ragged covering to the stem, as in most Monocotyledons. When a leaf of a dicotyledonous plant falls, it leaves a more or less distinct scar upon the stem called the *cicatrix*; the protuberance under the cicatrix is called the *pulvinus*.

A perfect leaf is divisible into two portions,—the upper portion, the blade or *lamina*, which is flatly expanded, and the basal portion, the leaf-stalk or *petiole*, which generally remains narrow or cylindrical. The petiole is sometimes absent; the leaf is then *sessile*, as in the poppy. When the petiole is expanded and forms a sheath to the stem, it is *vaginate*. In *Cyperaceæ*, the vagina forms an entire sheath; in *Gramineæ*, the vagina is split down at the side opposite to the lamina or blade; sometimes the petiole is winged, as in *Aurantaceæ* (Bátábi-nebú).

At the base of the petiole often occur leaf-like appen-

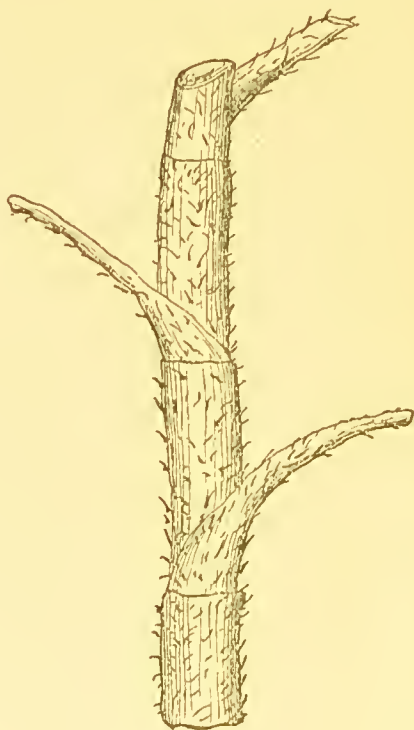
dages termed *stipules*; these may be considered as lateral branches of the leaves which arise at their points of insertion. *Stipules* are of different forms; in many *Rosaceæ* they are *adnate* (see Fig. 35). In many *Legumínosæ* (Krishnachúrú) and *Malvaceæ* (Java), they are *free*; in *Polygonaceæ* (Pání-marich), they form a short tubular sheath round the stem, called an *ochrea* (see Fig. 36). Leaves having such appendages are termed *stipulate*; where they are absent, *exstipulate*. The term *ligule* is applied to a membranous outgrowth on the inner side of the leaf in *Gramineæ* at the junction of the blade with the sheaths; the hood-like appendages of the stamens of *Asclepiadaceæ* are structures of this nature, and may be included under the general term of *ligulate* structures. When the leaf is united for a certain length with the stem, it is said to be *decurrent*, and the stem to be *winged*.

Fig. 35.



Portion of the stem of a Rose shewing a leaf with adnate stipules.

Fig. 36.



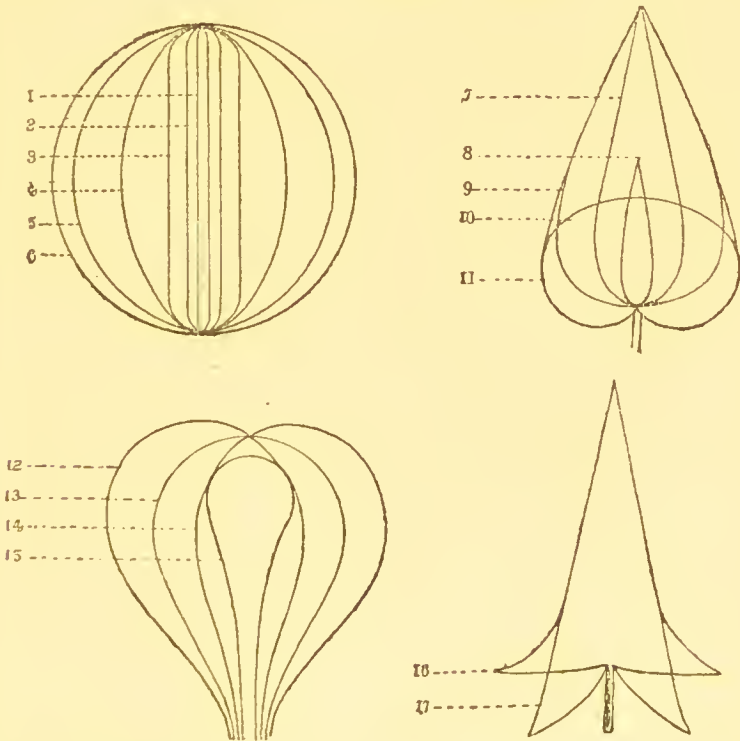
Ochraceous stipules of *Polygonum pilosum*.

Forms of Foliage Leaves.

The outline of leaves is either *simple* or *compound*; if the blade stands alone upon an undivided petiole, or is sessile on the stem, it is termed simple. Leaves are termed compound in which the individual pieces of the lamina are completely separated at their base. "If the individual portions of a branched leaf are sharply separated, each portion forms independently, so to speak, a leaf, and is hence distinguished as a *leaflet*."

The following diagrams (see Fig. 37) shew the principal outlines of simple leaves:—

Fig. 37.



Diagrams shewing the outlines of different simple leaves (after *Oliver*):

- | | | |
|----------------|----------------|-------------------|
| 1. Acicular. | 7. Lanceolate. | 13. Obovate. |
| 2. Linear. | 8. Subulate. | 14. Oblanceolate. |
| 3. Oblong. | 9. Cordate. | 15. Spathulate. |
| 4. Elliptical. | 10. Reniform. | 16. Hastate. |
| 5. Rotundate. | 11. Ovate. | 17. Sagittate. |
| 6. Orbicular. | 12. Obcordate. | |

Most of the Gramineæ have *linear leaves*. *Vinca rosea* (Galphringhi) has *elliptical leaves*; the leaves of *Zizy-*

phus (Byar) are rotundate, somewhat oblique at the base (Fig. 38). The leaves of *Nelumbium* (Padma) are orbicular;

Fig. 38.

Fig. 39.

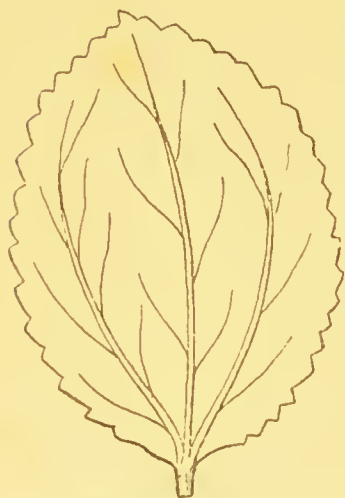
Rotundate leaf of *Zizyphus*.

Fig. 04.

Orbicular leaf of *Malva rotundifolia*.Lanceolate whorled leaves of *Nerium*.

Nerium has lanceolate leaves (Fig. 40); the common garden *Dianthus*, oblanceolate leaves; most of the *Convolvulaceæ* (Kalmilátá) have cordate leaves; the leaflets of *Oxalis corniculata* (Amrúl) are obcordate; the leaves of *Hydrocotyle Asiatica* (Thalkúrí) are reniform; ovate leaves occur in *Ficus Indica*; obovate in *Tectona grandis* (Según). Sagittate leaves are found in *Sagittaria sagittifolia* (Kat). The leaves of many *Begonias* are oblique.

A leaf is *peltate* when the lamina is fixed not by a portion of its margin, but by a point lying on its under surface, as in *Tropæolum*, *Nelumbium*, &c.

Fig. 41.

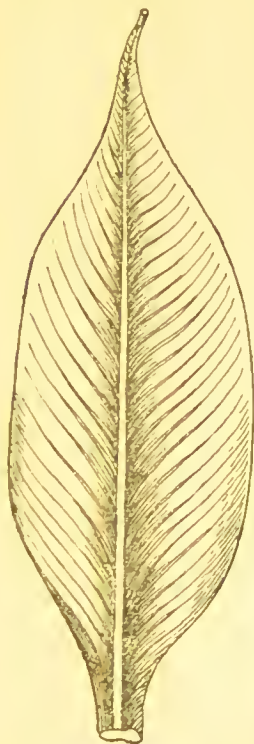
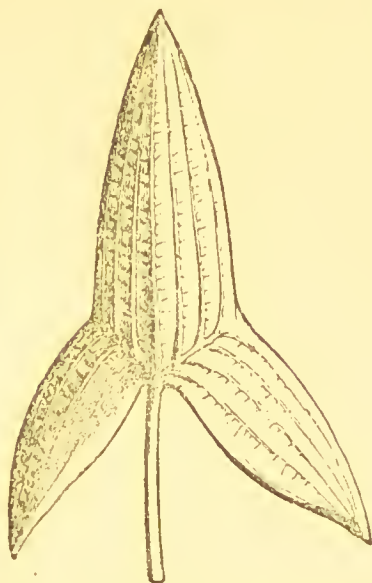


Fig. 42.



Penninerved leaf of *Canna Indica*. Sagittate leaf of *Sagittaria sagittifolia*.

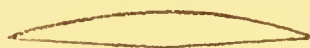
Fig. 43.



Oblique leaf of *Begonia*.

In describing the base of the leaf, some special terms are applicable, as for example, eordate, reniform, hastate, &c. The apex of the leaf requires special description: it is *acuminate* in *Ficus religiosa* (Ashwath); *acute*, in *Hibiscus Rosa-sinensis* (Javá); *obtuse*, when the leaf is rounded

Fig. 44.



Diagrams shewing entire and dentate margins of leaves.

Fig. 45.



Diagrams shewing crenate and bi-serrate margins of leaves.

Fig. 46.

Reniform leaf of *Hydrocotyle Asiatica*, with crenate margin.

off at the apex; *mucronate*, as in *Jaquina ruseifolia*, when it is tipped with a spine; *truncate*, as in *Ficus retusa*; *emarginate*, when there is a notch at the end of the midrib.

The margin of a leaf is *entire*, when it has an unbroken edge, as in the banyan; *dentate*, when the margin of the leaf is notched, as in *Hibiscus Rosa-sinensis* (Fig. 44); *serrate*, when the teeth are sharp and pointed towards the apex, like the teeth of a saw; *crenate*, when the teeth are rounded off, as in *Hydrocotyle Asiatica*. When the margin of the leaf exhibits shallow wavy curves, it is called *repand*, as in *Ficus religiosa*. Sometimes, through excessive growth of the marginal tissue, the edges of the leaf are *undulated*, or *waved*, as in *Guatteria longifolia* (Debdári). In *Croton spiralis*, the blade of the leaf is twisted like a screw through the excessive development of the marginal tissue. If

the blade is deeply cut, extending nearly to the midrib, the leaf is termed *pinnatisect* or *pinnatipartite*; *palmatisect* or *palmatipartite*, if the divisions extend nearly to the base of the leaf (see Fig. 47). The terms

Fig. 47.

Palmatisect leaf of *Cannabis sativa*.

pinnatifid and *palmatifid* are used when the divisions extend half-way or more from the margin to the mid-rib or base of the leaf, but not right up to the mid-rib or base (see Fig. 48).

Fig. 48.



Palmatifid leaf of an Euphorbiaceous plant.

leaves are termed *lobed*, as in *Bauhinia* (Káchan), which has a bilobed leaf.

Compound leaves are those in which the individual lateral

Fig. 49.



pieces of the lamina are completely separated at their base. There are two principal forms,—the *digitate* and the *pinnate* (see Fig. 49). In the former, several leaflets spring from the apex of the petiole, as in *Bombax Malabaricum* (Shemul). The terms *ternate*, *quinate*, *septenate* are often applied to digitate leaves having 3, 5, or 7 leaflets. When the lateral divisions of a ternate leaf have two or more lobes it is termed a *pedate* leaf, as in *Syngodium wendlandi*.

Pinnate leaf (frond) of a Fern.

Fig. 50.

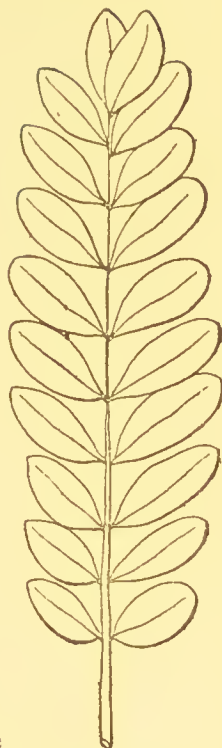


Bi-pinnate leaf of Persian Lilac.

Fig. 51.

Impari-pinnate leaf of
Murraya exotica.

Fig. 52.

Pari-pinnate leaf of
Tamarind.

Pinnate leaves are those having an axis bearing sessile, or stalked lateral leaflets arranged on the feather plan. Sometimes there is a terminal leaflet, as in *Murraya exotica* (Kamini): the leaf is then unequally pinnate, or *impari-pinnate* (see Fig. 51). When there is no terminal leaflet, as is the case in the tamarind, the leaf is equally pinnate or *pari-pinnate* (see Fig. 52). Pairs of leaflets are termed *juga*; if there is only one pair, the leaves are termed *unijugate*; if more pairs than one, *bipari*, or *multijugate*. If the leaflets are not in pairs, but alternate with one another, the leaf is termed *alternipinnate*. If large and small leaflets alternate with one another, the leaf is *interruptedly pinnate*. *Bi-pinnate* leaves are those in

Fig. 53.

Tri-pinnate leaf, as in *Moringa pterygosperma*.

Fig. 54.

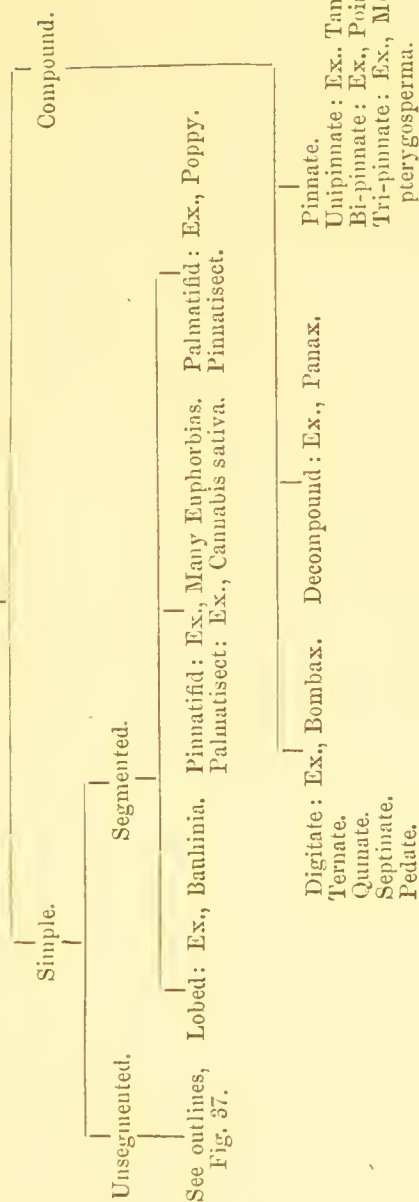
Decom-pound leaf of
Panax.

which the axis has secondary branches, with distinct leaflets pinnately arranged, as in *Poinciana pulcherrima* (Krishnachúra). *Tri-pinnate* leaves are those having an additional series of partial petioles with distinct leaflets, as in *Moringa pterygosperma* (Shajíná) (see Fig. 53).

A leaf cut into numerous compound divisions, as in *Panax*, is termed *decompound* (see Fig. 54). Some plants have leaves of different forms (*heterophyllous*), as *Sagittaria*, *Trapa*, and

many other water-plants, some of the leaves are submerged, while others rise above the surface water. The floating leaves of *Trapa bispinosa* (Páñiphal) are wedge-shaped, while the submerged leaves are segmented.

ABSTRACT OF THE FORMS OF FOLIAGE LEAVES.



The texture of leaves varies: in Crassulaceæ and Portulacacæ the leaves are *succulent*; in many asepadiaceous plants, they are *fleshy*; they are *coriaceous* or leathery in most woody plants, and *membranous* in many herbs.

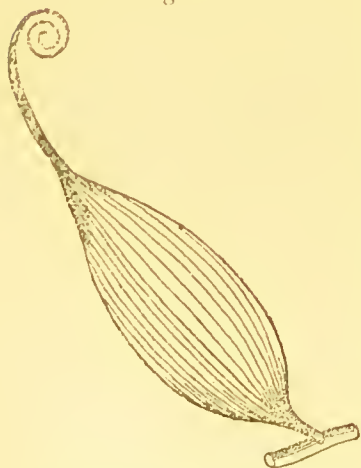
Fig. 55.



Ovate leaf of Banyan.

Tendrils, already referred to under the section climbing

Fig. 56.

A curvinnerved leaf of *Gloriosa superba* ending in a tendril.

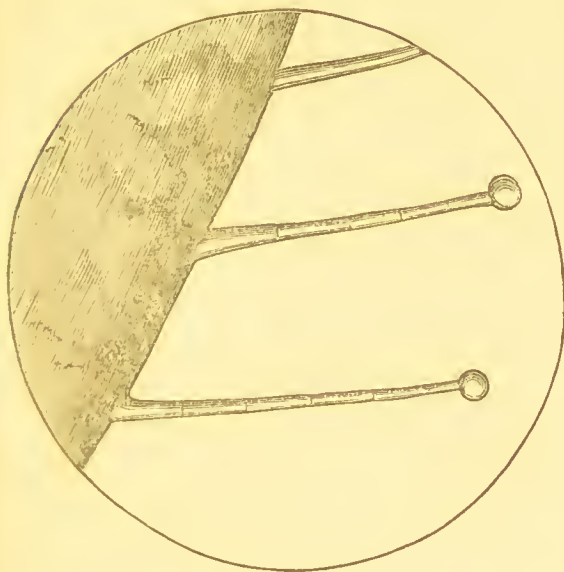
Modifications of the leaf occur in *Trapa* (Páni-phal), where the petioles are inflated and form floats. In *Utricularia* (Jhanji), there are bladder-like organs, closed at first by a lid developed from some of the segments of the leaves, and apparently serve as floats, and as traps for insects. Similar structures occur in the floats of *Jussiaena repens* and *Desmanthus nutans*. The metamorphosed leaves of the *Nepenthes*, or *Pitcher plant*, are formed by peculiar modifications of the petiole and blade.

Tendrils, already referred to under the section climbing stems, are thread-like processes, by which weak-stemmed plants attach themselves to foreign bodies. Tendrils formed from metamorphosed leaves occur in *Gloriosa superba*, where the mid-rib runs on into a terminal tendril (see Fig. 56). In *Smilax*, the stipules are represented by a pair of tendrils. In *Lathyrus aphaca* (Janglí-matar), the tendrils are metamorphosed leaves, the leaflets being entirely abortive, and replaced by the foliaceous stipules. In *Lathyrus sativus* (Khesari), two pairs of leaflets remain, the other leaflets being transformed into tendrils.

Hairs.

The surfaces of leaves, &c., exhibit a variety of conditions, dependant on the character of the epidermal layer of tissue.

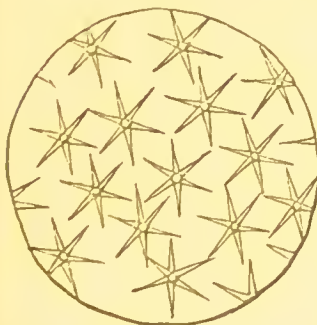
Fig. 57.



Glandular hairs from under-surface of a leaf
(magnified).

cells, plates of cells, or masses of tissue, or have the physiological character of woolly envelopes of the young leaves, root-like absorbing organs (mosses), glands, prickles, or spore-capsules (Ferns)."

Fig. 58.



Stellate hairs from the under-surface of a leaf of *Solanum Melongena*.

The surface of the leaf is *pubescent*, when covered closely with short soft hairs, as in *Calatropis gigantea* (Akanda); *villous*, when the hairs are long and weak; *hispid*, when the surface is covered with scattered stiff hairs. The terms *woolly*, *felted*, and *silky* are applied according to the coarseness of the hairs and the thickness of the coat they form. *Peltate hairs* occur upon the under-surface of the leaves of *Elæagnus*; *glandular hairs* (see Fig. 57), on the leaves of *Labiatae*, &c.; *stellate hairs* (see Fig. 58), on the under-surface of the leaves of *Solanum*, &c.

Sometimes the base of the hair contains an acrid fluid ; it is then called a *sting*, as in *Urtica interrupta* (Lallichatí). *Prickles* (Fig. 59) are hardened epidermal appendages, as in *Solanum melongena* (Begún), *Rosa*, &c. ; they are like hairs, outgrowths from the epidermal tissue, whereas *spines* have a deeper origin.

Fig. 59.



Prickles on the stem of a Rose.

The Flower.

The flower is the assemblage of organs connected with the production of the seed. As far as external appearance goes, the flower of Angiosperms (Dicotyledons and Monocotyledons) is an altogether peculiar structure, sharply differentiated as a whole from the rest of the organism. This peculiar appearance is due especially to the foliar structures of the flower being arranged, with rare exceptions, in the form of whorls. The floral envelope or *perianth* is only rarely wanting ; it is usually composed of two alternating whorls consisting of the same number of leaves, 2, 3, 4, 5, or rarely more. In most dicotyledons, and many monocotyledons, the form and structure of these two whorls is very different ; the outer whorl or *calyx* consisting of stouter, green, usually small leaves (*sepals*), while the inner whorl or *corolla* is more delicate, and is formed of white or bright coloured, usually larger leaves (*petals*). Occasionally the perianth is entirely wanting, as in the Piperaceæ and many Aroideæ. Sometimes the perianth consists of only one whorl composed of small green leaves, as in the Chenopodiaceæ and Urticaceæ, or of larger bright coloured leaves, as in Nyctaginaceæ and many Euphorbiaceæ. For these conditions the terms *diclamydeous*, having calyx and corolla, *monoclamydeous*, having only a single floral envelope, and *aclamydeous*, destitute of a perianth, are used by most systematic botanists. Besides the perianth abovementioned, there are often additional envelopes to the separate flowers. In the Malvaceæ and some other plants the true calyx is surrounded by a second calyx (*epicalyx*). In the majority

of flowers, the members of each successive whorl *alternate* with those of the preceding whorl; in the Vitaceæ, Rhamnaceæ, Urticaceæ, and Loranthaceæ, etc., the stamens are placed opposite or *superposed* to the petals.

The essential parts of the flower are the stamens (*andracium*), and the carpels (*gynacium*). Flowers having both essential organs are termed *hermaphrodite*, as Hibiscus, Calotropis, &c. Sometimes the stamens alone are present; the flower is then *staminate*, or male; if, on the other hand, the carpels alone are present, but the stamens absent, the flower is *pistillate*, or female. Those flowers in which either stamens or carpels are wanting, are termed *diclinous*, or unisexual, as in the Cucurbitaceæ; if the same plant bears distinct male and female flowers, the flowers and plants are *monœcious*, as many Cucurbitaceæ. Occasionally

Fig. 60.

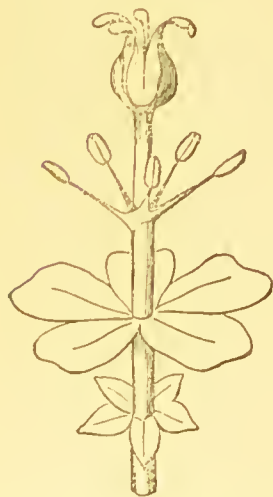
Male flower of *Carica Papaya*.

pistillate and staminate flowers occur on distinct plants, as *Trewia nudiflora* (Pitali), *Carica papaya* (Pepiya) (see Figs. 60 and 61), *Borassus flabelliformis* (Tál), and *Phoenix sylvestris* (Khajur); such flowers and plants are termed *diœcious*; some imperfect flowers possess neither carpels nor stamens, as the outer flowers of the capitula of *Centaurea*, &c., they are then termed *sterile*, or neuter. In some

Fig. 61.

Female flower of *Carica Papaya*.

Fig. 62.



Diagrammatic illustration of a flower, shewing the carpels, stamens, petals, and sepals separated by distinct internodes.

plants, as in the *Anacardiaceae*, male, female, and hermaphrodite flowers are found on the same individual; such plants are termed *polygamous*. In *Gymnospermia* the floral axis is usually elongated to such an extent that the sexual organs are arranged one above another in alternate whorls or in spirals: in *Angiospermia*, on the contrary, the floral axis which bears the floral envelopes and sexual organs is so abbreviated that space can only be found for the

various foliar structures by a corresponding expansion, or increase in size of that part of the floral axis which bears them; this part of the floral axis is termed the *Thalamus Torus*, or *receptacle*. Beneath the receptacle the axis is mostly elongated and more slender, and is termed the *peduncle*; if the peduncle is absent or very short, the flower is *sessile*. Occasionally portions of the axis are greatly elongated within the flower (see Fig. 62), as occurs in many plants of the *Capparidaceae*. When a circle of organs of the flower is thus removed from its predecessor by a stalk-like internode, it is termed *stipitate*: the term *androphore* is used for that portion of the axis supporting the stamens; *gynophore*, or *carpophore*, for that bearing the carpels; that portion of the axis supporting both stamens and carpels is termed *gynandrophore*.

All the different parts of the flower frequently stand free on the receptacle, as in the *Papaveraceae* (*Shelkátá*);

the flower is then *thalamifloral*. When the sepals, petals, and stamens adhere to one another, the flowers are *calycifloral*, as in the *Myrtaceæ* (Peyará); when, as in the *Labiataæ*, *Solanaceæ* (Begún), &c., the stamens adhere to the corolla alone, the flowers are termed *corollifloral*.

When union takes place between members of the same whorl, the term *cohesion* is applied as in the stamens of *Malvaceæ* and the petals of *Solanaceæ*. The term *adhesion* is used when members of different whorls unite one with the other, as the stamens and corolla of *Labiataæ* and *Solanaceæ*, &c.

A flower consisting of the four whorls is termed complete, or *eucyclic*. When the members in each whorl are similar, the flower is *regular*: the flowers of *Labiataæ* are irregular; those of *Papaveraceæ*, regular. When the number of members in one whorl is equal in number, and alternate with those in the other whorls, the flower is *isomerous* or *symmetrical*, as in the *Irideæ*, some *Linaceæ*, *Onagraceæ*, and *Crassulaceæ*. When the perianth and androecium are both present, the number of their parts is usually the same, or the flower is *isostemonous*, but the stamens are often more, rarely fewer in number than the parts of the perianth, and the flower is then *anisostemonous*.

The Inflorescence.

A solitary flower, or a connective system of flowers arising from one point, is called an *inflorescence*, and may be either *terminal* or *axillary*. The term *peduncle* is that usually given to the stalk supporting a single flower or numerous flowers, which are either sessile, as in the catkin, or are placed on small stalks termed *pedicels*, as in the raceme. When the peduncle bears a number of spikes or racemes, as in the panicle, it is often termed a *rachis* or *axis of the inflorescence*. The term *scape* is applied to a stem devoid of foliage leaves, arising under ground and bearing the inflorescence, as in *Nelumbium*.

The most convenient basis for the classification of the forms of inflorescence is the mode of branching (see branching, page 15). This is less variable than the other features, and can be referred to a few types. The different forms may thus be divided into two classes:—1st, the *indeterminate*, centripetal or racemose, results from the primary axis or rachis of the branching system producing a larger

or smaller number of lateral shoots ; and 2ndly, the *definite*, centrifugal, or cymose, which results from the primary axis branching beneath the first flower in such a manner that each lateral axis terminates in a flower ; the development of each lateral shoot is stronger than that of the primary axis beyond the point of origin :

(a) Of the forms of indefinite inflorescence the following are the most important :—the *spike*, the *raceme*, the *corymb*, the *panicle*, the *umbel*, and the *capitulum*.

1st.—The *spike* is an axis bearing sessile flowers, as in Aca-thaceæ and Musaceæ. A *spadix* is a spike with a thick fleshy axis surrounded by a *spathe*, as in Aroidæ. In the Palmææ, the axis (spadix) is branched. A *catkin*, or *Ament*, is a pendent spike-like inflorescence, eaducous, as in *Trewia nudiflora*. The flowers in catkins are usually unisexual. A *cone* is the

Fig. 63.



Diagram of a raceme and spike.

spike-like inflorescence of many *Cynospermia* (in this case the carpellary leaves are persistent and do not form an ovary).

2nd.—The *raceme* is an inflorescence in which there is a primary axis bearing stalked flowers, as in *Cruciferae*, *Capparidaceæ*, &c.

Fig. 65.

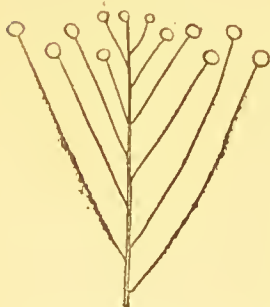


Diagram of a corymb.

3rd. — The *corymb* is a raceme in which the lower stalks are elongated, so as to bring all the flowers to about the same level, as in some plants of the genera *Euphorbia*, *Jatropha*, &c. (see Fig. 65).

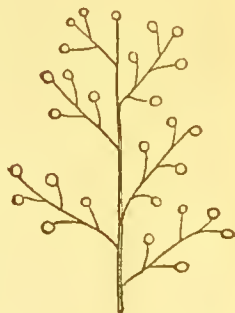
4th.—The *panicle* is a series of racemes, umbels or

Fig. 64.



Compound spadix and spathe of a Palm.

Fig. 66.



Diagrammatic sketch of a racemose panicle.

spikes, &c., on a branched rachis, as in the mango, *Clerodendron viscosum* (Bhánt), *Saraca Indica*, &c. It is the common form of inflorescence met with in many Gramineæ.

5th.—The *umbel* is formed of a number of single flowers borne on stalks of nearly equal length, arising from one point. The umbel may become compound by the peduncles branching, as in the Umbelliferae; this inflorescence is surrounded by a peculiarly developed whorl of leaves (involucre).

6th.—The *capitulum* is a rachis expanded into a thickened mass surrounded by an *involucre* of bracts, as in the Compositæ; the individual flowers are sometimes called *florets*: the outer ones, florets of the ray; the inner ones, florets of the disk. Modifications of the capitulum, in which the involucre is wanting, and the peduncle fleshy and excavated, occurs in *Ficus*, &c. In *Dorstenia* the flowers are imbedded in the flat fleshy receptacle; while in *Artocarpus* 'Jack,' the receptacle is convex.

(b) The forms of definite cymose or centrifugal inflorescence agree in producing a primary terminal flower on each shoot; the succeeding flowers spring from the lateral branches. The term *scorpioid* was introduced by A. P. De Candolle to express a unilateral cyme, the undeveloped portion of which is usually rolled up; it is the characteristic inflorescence of the Boraginaceæ (see Fig. 67).

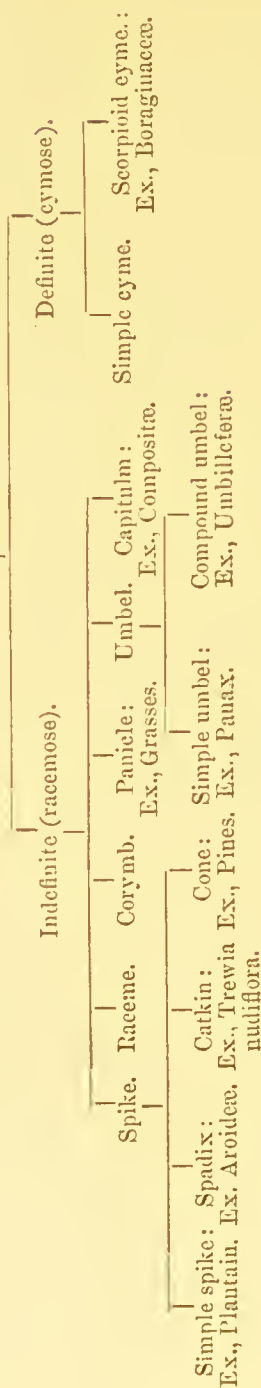
Fig. 67.



A branch of *Heliotropium indicum* shewing the scorpioid inflorescence.

In the Labiatae, the individual inflorescence is cymose, the cymes being indefinitely developed on the axis. An inflorescence is *fasciated* when the peduncles are congenitally fused together, as in *Celosia cristata* (Lalmurga).

FORMS OF INFLORESCENCE.



The Calyx.

Fig. 68.



A rose, in which the sepals have been replaced by foliage leaves from a rose-tree grown in the Hughli Botanical Garden.

The calyx is the external covering of a diclamydeous flower; it is generally green, and consists of a whorl of leaves or sepals. It is occasionally double, as in the Malvaceæ; the outer circle being then termed an *epicalyx*. This epicalyx may be regarded as an involucre of bracts.

Fig. 69.



Mussaenda macrophylla, shewing one of the sepals enlarged and leaf-like.

Sepals have generally a broader base than petals, are sessile, usually have a very simple outline, and are pointed at the apex. In a gamosepalous calyx the part where the sepals are coherent, is the *tube*; the upper portion of the tube is termed the *throat*, and the free spreading portions *lobes* or *teeth*. When the sepals are completely coherent, so that the compound nature of the calyx is not indicated by the teeth or lobes at the edge, it is termed *entire*.

Fig. 70.



Spurred calyx of *Tropaeolum*.
occurs in the Cruciferae. The terms *inferior* and *superior* are applied to the calyx according as it is free or adherent to the pistil.

In *Holmskjoldia Sanguinea*, *Larkspur*, *Tropaeolum*, and *Begonia*, the calyx is brightly coloured, as is also frequently the case in *Monocotyledons*.

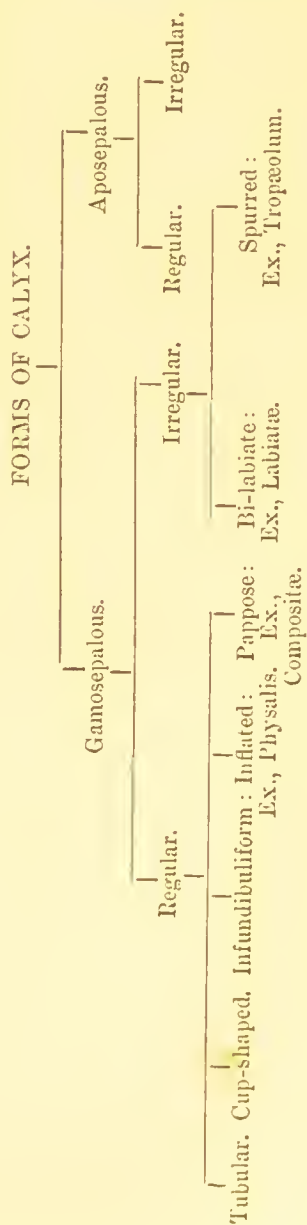
A calyx consisting of coherent leaves is *gamosepalous* or *synsepalous*; if the leaves are not coherent but free, this is expressed by the term *aposepalous*. Sepals

The gamosepalous calyx may be regular or irregular. The regular forms may be termed *tubular*, *cup-shaped*, *infundibuliform*, or funnel-shaped, and *inflated*. The principal irregular form is *bi-labiate*; this is particularly characteristic of the order *Labiatae*. The base of the calyx is sometimes *spurred*; as in *Tropaeolum* (see Fig. 70): *saccate* in *Salvia coccinea*; *gibbous*, where a shallow-pouch is formed at the base of the calyx, as frequently

The duration of the calyx varies. In the *Papaveraceae* it is *caducous*, falling off when the flower opens. It is *deciduous*, if it falls off with the corolla, as generally happens in most flowers, soon after the fertilization of the

ovules. It is *persistent* in *Dillenia* (Chálitá), in the Labiatae, some Solanaceae, &c. In the place of the calyx of Compositae, a crown of hairs, the *pappus*, surrounds the corolla. In *Datura*, the lower portion of the calyx is persistent, while the upper part separates by a circular slit. Occasionally, as in *Physalis* (Tepari), and in some Verbenaceae, &c., the calyx grows during the ripening of the fruit, completely enveloping it; it is then termed *accre-scent* (Fig. 71). The term *marcescent* is sometimes applied to the calyx when it withers, but does not fall away from the thallamus during the ripening of the fruit, as in the Nyctaginaceae. In *Trapa*, the horns of the fruit are formed by the lignification of the calyx teeth.

Fig. 71.

Accrescent calyx of *Physalis*.

The Corolla.

The corolla is composed of all the leaf-like members, situated between the calyx and the stamens or carpels. These are individually called *petals*, and may exist in one or more

Fig. 73.

Fig. 72.



Papilionaceous corolla.

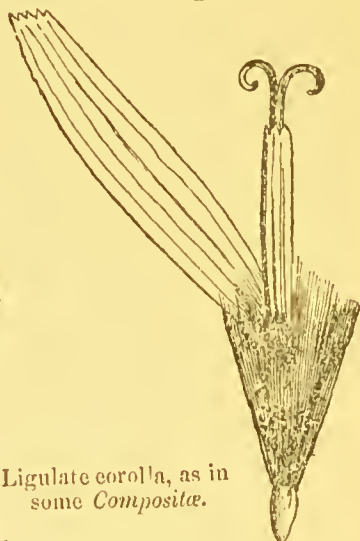
Ligulate corolla, as in
some *Compositæ*.

Fig. 74.



Petunia grown in the Horticultural Society's Garden, Calcutta, in which the ordinary sepals and petals are replaced by foliage leaves.

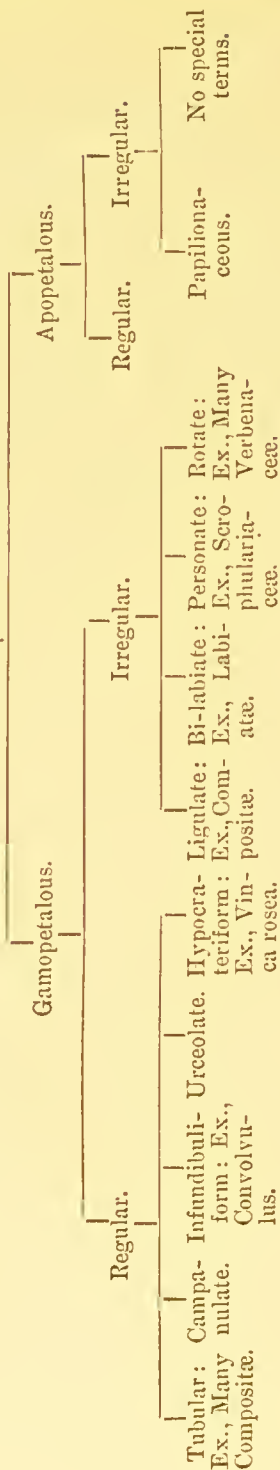
circles, as in *Datura* and *Lotus*. Petals have mostly a narrow base; their upper portion is often very broad, and a distinction is not unfrequently apparent of *claw* (unguis) and *blade* (lamina), and the lamina is often divided or otherwise segmented. At the point where the lamina bends back from the unguis, ligular structures are often formed on the inner or upper side, which are then, when treating the flower as a whole, comprised under the term *corona*, as in the *Passifloraceæ*, *Nerium*, &c.

A corolla consisting of coherent leaves (petals) is gamopetalous or sympetalous; if the leaves are free, this is expressed by the term apopetalous.

Apopetalous corollas are regular when the petals are equal in size and symmetrically arranged, as in the *Papaveraceæ* and *Rosaceæ*. Irregular apopetalous corollas occur in the *Umbelliferæ* and in the *Papilionaceæ* (a sub-order of the *Liguminosæ*), where the corolla is termed *papilionaceous*; it is composed of five petals (see Fig. 72), of which the posterior (the *vexillum*) is the largest, and is usually symmetrical in form; the two lateral are smaller, and are mostly oblique, forming the *alæ*, or wings; the two anterior are also usually smaller and oblique, often coherent in front, and form the *carina*, or keel. Irregular corollas occur also in the *Fumariaceæ*, *Violaceæ*, *Balasanineæ*, &c.

Gamopetalous corollas, like gamosepalous calyces, have frequently a tube, a throat, and a limb; they are regular or irregular. The regular forms are *tubular*, as in many of the *Compositæ*; *campanulate*, as in some *Solanaceæ*; *funnel-shaped*, or *infundibuliform*, as in *Convolvulaceæ*; *urceolate*, as in *Ericaceæ*; *hypocrateriform*, or salver-shaped, as in *Vinca rosea* and *Jasminaceæ*. Irregular gamopetalous corollas occur in the ray florets of many *Compositæ* (see Fig. 73) (and all the corollas are ligulate in the tribe *Cichoraceæ* of the same order), where they are termed *ligulate*. In *Labiataæ* the corolla is usually *bi-labiate* or two-lipped, the upper lip being formed of two, the lower of three more or less coherent petals. The mouth of the corolla is sometimes closed by a cushion-like formation, (*personate* corolla), as in *Lindenbergia* and many other *Scrophulariaceæ*; in this condition also the base of the corolla is frequently swollen (*gibbous*).

FORMS OF COROLLA.



The Perianth.

The term *perianth* is specially employed when the two circles of the floral envelope are similar in size and colour. A large number of the Monocotyledonous orders

Fig. 75.



Petaloid perianth of a lily.

possess a petaloid perianth, which may be regular or irregular. Where there is only one perianth whorl, and it is desired to state whether it consists of coherent or of free leaves, the terms *gamophyllous* or (*symphyllous*) *apophyllous* may be used. In *Amaryllis* there is a regular apophyllous perianth; in the *Zingiberaceæ*, *Marantaceæ*, and *Orchideæ*, there are irregular apophyllous perianths. *Aristolochia Indica* has an irregular gamophyllous perianth; *Polygonaceæ*, a regular gamophyllous perianth.

FORMS OF PERIANTH.

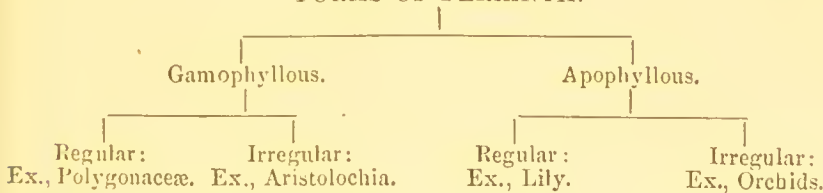


Fig. 76.

Irregular
perianth of
Aristolochia
Indica.

The orchidaceous perianth requires special notice, as it presents a great variety of forms; the three outer members are more or less alike, and are generally smaller than the inner series, the anterior one of which is called the *labellum*. Besides the usual sepaloid and petaloid forms and structures of the perianth leaves, there occur other considerable deviations from the ordinary foliar structure; thus, for example, the imperfect perianth of grasses consists of very small delicate, colourless, membraneless scales (the *lodicule*); that of some *Cyperaceæ* is replaced by hair-like bristles (*setæ*).

The Andrœcium.

The Andrœcium is composed of the assemblage of the male sexual organs of a flower. Each separate organ is called a *stamen*, and consists of the *anther* and its stalk, the *filament*. The anther consists of two longitudinal halves (anther-lobes) placed on the upper part of the filament, right and left of its median line; the portion of the filament inserted between the anther-lobes is the *connective*; when the filament is wanting, the anther is sessile.

Staminodes are sterile stamens devoid of anthers, and occur in many flowers, as in *Bauhinia* and many other of the *Leguminosæ*. These staminodes are reduced to glandular papillæ, in the flowers of many *Cruciferae*.

Fig. 77.

Versatile
anther of
Amaryllis.

The filaments are usually *filiform* (thread-like), as in the *Papaveraceæ*; sometimes they are *capillary* (hair-like), as in *Gramineæ*. They are *flattened* in *Aurantieæ*; *petaloid* in *Marantaceæ*, *Zingiberaceæ*, and *Nymphæaceæ*. When the filament is attached to the base of the connective, like the petiole of a foliage leaf, it is *innate*, as in *Lemna*, *Hiptage*, &c. In many flowers, the anther is *adnate*,—i.e., it is united throughout its whole length to the filament, as occur in most flowers. In *Gramineæ* and *Passifloraceæ*, the anther is *versatile*, the filament being attached by a slender apex to the middle of the back of the anther. The number, mode of attachment, and relative length of the filaments are of importance in connection with classification

(see page 79).

In nearly all *Labiatae*, *Verbenaceæ*, *Serophulariaceæ*, *Acanthaceæ*, *Gesneraceæ*, and *Bignoniaceæ* there are two short stamens and two long ones (*didynamous*). In *Cruciferae* there are six stamens, two shorter than the others (*tetradynamous*). When longer than the corolla tube, the stamens are *exserted*. "A phenomenon of great importance from a morphological point of view is the branching of stamens which occurs in many *Dicotyledons*,

a peculiarity of structure which was erroneously confounded by the older botanists with their cohesion, although the two are fundamentally distinct" (*Sachs*). When the filaments form a tube round the style, the stamens are *monadelphous*, as in the *Malvaceæ*, *Sterculiaceæ*, and *Meliaceæ*, &c. When they are in two equal bundles, as in *Fumariaceæ*, or in unequal bundles, as in most of the *Papilionaceæ*, where nine of the stamens are united, and one free, they are *diadelphous*. In many *Hypericaceæ*, they are *triadelphous*; and in *Aurantiaceæ*, they are *polyadelphous*. When the

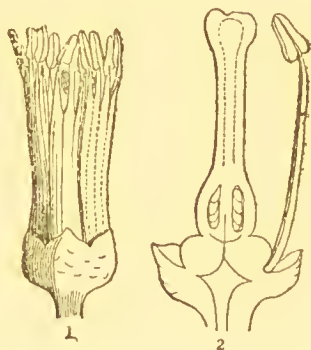
Fig. 78.

Monadelphous stamens of *Malvaceæ*.

Fig. 79.

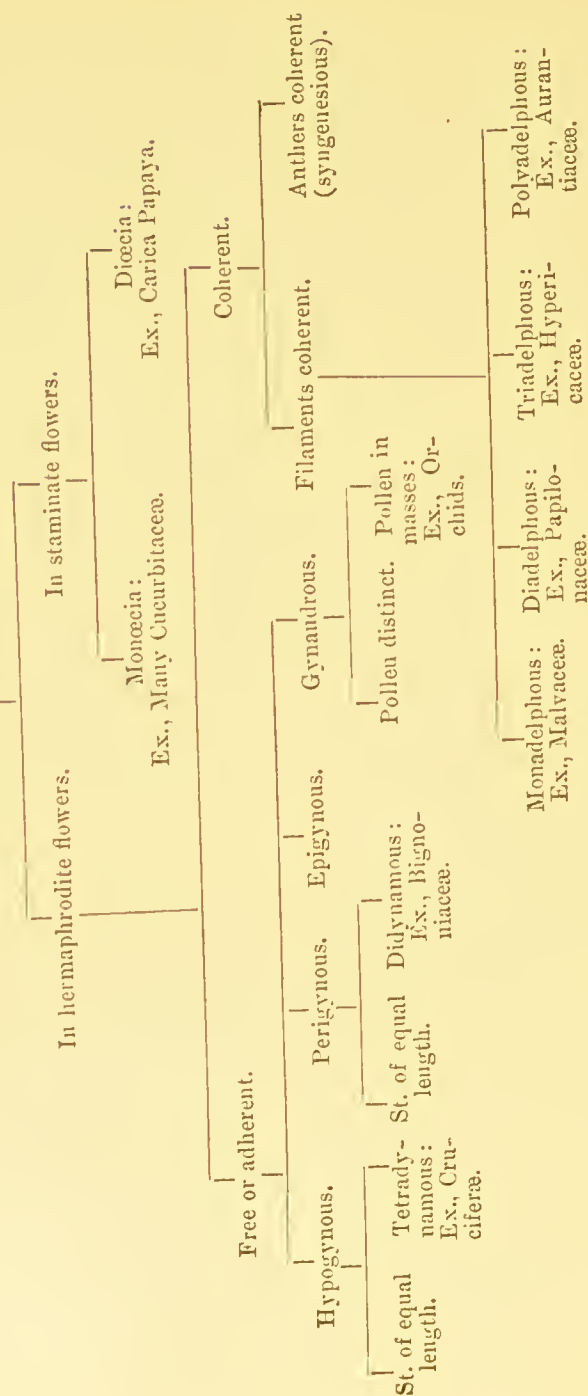
Diadelphous stamens of *Leguminosæ*.

Fig. 80.

Polyadelphous stamens and disk of *Aurantiaceæ*.

filaments are free, and the anthers coherent, the stamens are *syngenesious*, as in the *Compositæ* and *Lobeliaceæ*. Occasionally the stamens adhere to the carpels (*gynandrous*), as in *Orchideæ* and *Asclepiadaceæ*. When the axial part of the flower (the receptacle or torus) is so elevated in the centre that the base of the gynæcium lies above the stamens, or at least in the middle of the andrœcium, the perianth and andrœcium, or even the whole flower, is said to be *hypogynous*, as in the *Ranunculaceæ*, *Papaveraceæ*, etc. When, on the contrary, the receptacle is hollowed, bearing the perianth on its margin while the gynæcium springs from the bottom, the flower is said to be *perigynous*, as in the *Rosaceæ*, etc. The flower is finally *epigynous* when it possesses an inferior ovary, as in the *Myrtaceæ*, *Umbelliferae*, etc. (*Hypogynous* is synonymous with *thallamifloral*; see page 37.)

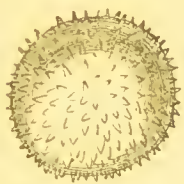
FORMS OF THE ANDRÆCIUM.



The male sexual cells (*pollen grains*) are formed in the cavities of the anther-lobes (*loculi*). The pollen grains arise in receptacles termed *pollen sacs*; in the young state there are usually four pollen sacs produced, two for each anther-lobe, and when these remain permanently distinct, a *quadrilocular* or tetralocular anther is the result; usually, however, only

two cavities remain in the anther by the union of the sacs in each lobe; in this case the anther is *bilocular*; sometimes the anthers have only a single cavity (*unilocular*), as in the *Malvaceæ*, *Amarantaceæ*, etc.

Fig. 81.

Pollen grain of *Cucurbita* (magnified).

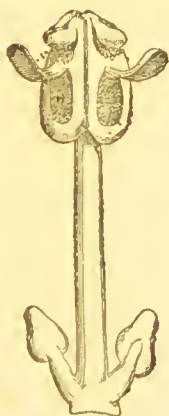
In most plants, the pollen consists of minute yellow granules, distinct from one another; in *Asclepiadaceæ* and *Orchideæ*, however, the pollen remains permanently coherent into masses termed *pollinia*, sometimes furnished with a stalk-like process, the *caudicle*, terminating in a glandular base, the *retinaculum*, by which they adhere to foreign bodies.

When the anthers are mature, they burst open or *dehisce* to discharge the pollen. This dehiscence usually takes place on the side nearest to the gynæcium (*introrse*); occasionally the dehiscence takes place at the side of the anther furthest away from the gynæcium (*extrorse*); the anthers usually burst by a longitudinal fissure in each

Fig. 82.

Anther of *Senna* opening by pores at the apex (enlarged).

Fig. 83.

Anther of *Laurus* opening by valves (enlarged).

anther-lobe (*longitudinal dehiscence*). The anthers of *Lemna* open by transverse slits (*transverse dehiscence*); sometimes the pollen escapes by orifices in the wall of the anther (*porous dehiscence*), as occurs in *Solanum*, *Senna*, *Ericaceæ*, *Guttiferæ*, *Polygalaceæ*, *Euphorbiaceæ*, &c. *Opercular dehiscence* results from a partial separation of a portion of the wall of the loculus in the form of a lid, as in *Laurus*.

The Gynæceum, or Pistil.

The distinguishing character of the *Phanerogamia* (flowering plants), as contrasted with the *Cryptogamia* (non-flowering plants), lies in the formation of the seed. This organ is developed from the ovule, which in its essential part, the nucleus, produces the embryo-sac. Flowering

plants may be classified as follows :—1st, the Gymnospermia, in which the ovules are not enclosed in a structure (the ovary) resulting from the cohesion of carpellary leaves ; 2nd, the Angiospermia, in which the ovules are produced in the interior of a structure (the ovary) formed by the cohesion of carpellary leaves, often only of one carpel, the margins of which have become coherent. The lower hollow portion enclosing the ovules or rudimentary seeds is the *ovary* ; the middle attenuated portion, the *style* ; and the uppermost glandular portion, the *stigma*. The stigmas are glandular swellings or expansions of various forms which retain the pollen that is carried to them, and by means of the moisture which is excreted from them induce the emission of the pollen tubes. The stigma may be *capitate*, as in the Liliaceæ ; *feathery*, as in Gramineæ ; *linear*, as in Compositæ ; *lateral*, as in Leguminosæ : in Labiatae and Boraginaceæ the four lobes of the bi-locular ovary form strong protuberances (see Fig. 122), so that the style finally appears to spring from between four parts of the ovary which seem to have scarcely any connection with one another, and is hence termed a *gynobasic* style. Sometimes, as in Papaveraceæ, the styler portion does not exist ; the stigma is then sessile on the ovary.

The number of carpels is frequently less than that of the organs in the outer whorls, being often reduced to two (dicarpis), as in the Apocynaceæ, Solanaceæ, &c. In the Leguminosæ, Urticaceæ, &c., there is only a single carpel ; multiplication of the carpels is frequent in the Cohort Ranales. In the Orchideæ, Liliaceæ, and other Monocotyledons, the agreement of the number of carpels with the organs in the other whorls is almost universal. The Gynæceum is superior in hypogynous (poppy) and perigynous (rose) flowers ; inferior in epigynous ones (plantain). The ovary is *monocarpellary* when it consists of only a single carpel, the margins of which are coherent, so that the mid-rib runs along its back (dorsal), and the ovules when they are marginal (ventral) form a double row opposite to it. A *polycarpellary* ovary is always the result of the union of all the carpels of a flower, the number being usually two, three, four, or five, arranged in one whorl. If the separate carpels remain open and cohere in such a manner that the

right margin of one unites with the left margin of another, the result is a *unilocular polycarpellary* ovary, as in Papayaceæ. A *bi-* or *multi-locular polycarpellary* ovary results when the margins of the carpels project inwardly so far that they meet or cohere either in the axis or periphery of the ovary. The term *apocarpous* is used for an ovary formed from numerous distinct carpels; *syncarpous* for an ovary formed from several united carpels. The following abstract clearly shows the different forms of Gynæceum:—

FORMS OF THE GYNÆCEUM (after Sachs).

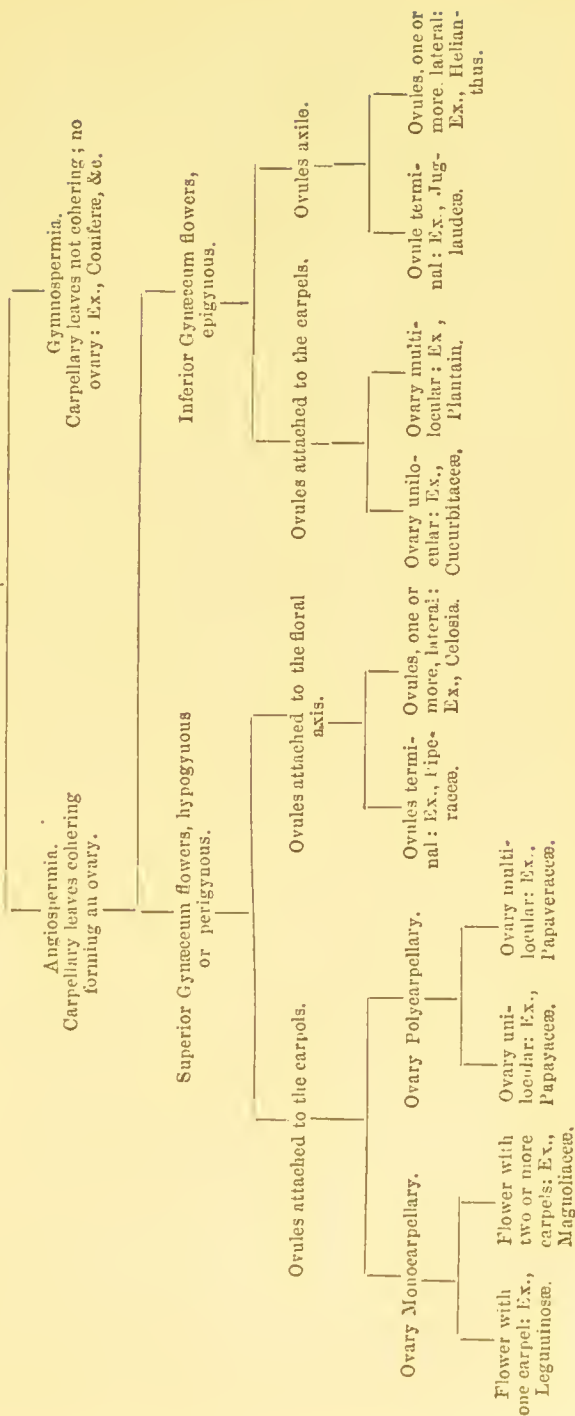


Fig. 84.

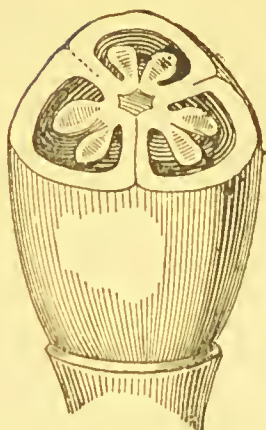


Diagram shewing multilocular polycarpellary ovary of plantain.

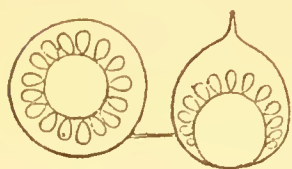
Fig. 85.



Diagram shewing unilocular polycarpellary ovary of violet, formed from 3 carpellary leaves. A similar ovary occurs in Papaya, formed from 5 carpellary leaves.

The region of the carpel or axis from which the ovules arise, is called the *placenta*; the ovules are either sessile or attached to the placenta by a stalk, or *funiculus*. In some cases the whole of the interior wall of the ovary serves as a placenta, as in *Papaveraceæ* and *Nymphæaceæ*. In *Piperaceæ*, *Helianthus*, &c., the ovules are produced from the prolongation of the floral axis,—the carpels themselves being sterile, the ovules are then *axile* (see Fig. 86).

Fig. 86.



Horizontal and vertical diagram, shewing axile placentation.

Fig. 87.

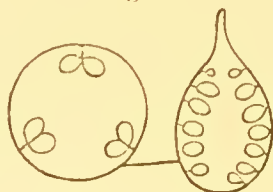
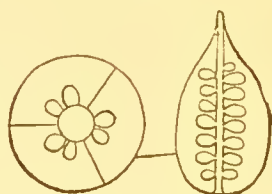


Diagram shewing the structure of parietal placentation.

Fig. 88.



Diagrammatic sketch of central placentation.

More frequently portions of the inner walls of the carpels project inwards, and bear the ovules (*parietal placentation*) (see Fig. 87), as in *Cohort Parietales*. In multilocular ovaries, the placentas of the infolded carpels are retroflexed, constituting *central placentation* (see Fig. 88), as the *Liliaceæ*, *Solanaceæ*, *Scrophulariaceæ*, &c.

The ovule arises from the placenta as a conical papilla, which soon becomes elongated into an oval body—the *nucleus* enclosed in a single, or more usually in a double, coat or integument. These coverings are formed by rings of cellular tissue growing up around the base of the nucleus, and all but enveloping it. The outer coat is termed the *primine* or *testa*; the inner coat, the *secondine* or *tegmen*. The coats do not completely cover the nucleus, but leave an opening at its summit, called the *micropyle* or *foramen*; the base of the nucleus, where the coats arise, is called the *chalaza*.

The orifice named the micropyle forms a canal passing through both coats; the portion passing through the outer, or *testa*, is called the *exostome*; that through the inner, the *endostome*. In the interior of the nucleus is a large cell, called the *embryo-sac*, within which the embryo (rudimentary plant) is formed.

With regard to their form, ovules may be divided into three kinds: 1st, the *orthotropous*, in which the ovule is straight, as in *Polygonaceæ*, and where the micropyle is exactly opposite the

chalaza. 2nd, *campylotropous*, in which the ovule is curved, formed by the bending over of the nucleus, upon itself, in the form of the letter U, as in *Caryophyllaceæ*; in this case the micropyle and the chalaza are almost in contact. 3rd, *anatropous*, as in *Cucurbitaceæ* and *Liliaceæ*, where the ovule is itself inverted, so as to bring the micropyle near the base, while the nucleus remains straight. The integuments (or at least the outer one)

have united in growth with the ascending funiculus, which, so far as this union is complete, is termed the *raphe*. When the ovule is half inverted, the term *amphitropous* is sometimes used.

Fig. 89.



Orthotropous
or Atropous
ovule of *Polygonaceæ*.

Fig. 90.



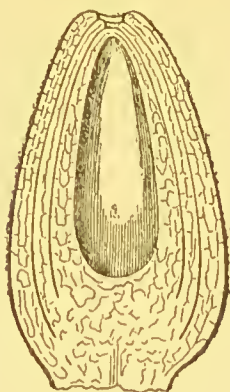
Campylotropous
ovule of *Portulacaceæ*.

Fig. 91.



Anatropous
ovule of *Cucurbitaceæ*.

Fig. 92.

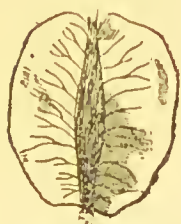


Orthotropous ovule shewing nucleus, tegmen, testa, &c.

The Fruit.

The *fruit* is the mature pistil (gynæceum); it must be most clearly borne in mind that the fruit is not a new plant structure; the only new parts in a morphological sense are the embryo and the endosperm which are produced in the ovule. The covering of the fruit is a substance formed from the carpels, or from some other parts of the flower, and is called the *pericarp*. In *Datura*, the

Fig. 92a.



Winged seed, as
in *Moringa ptery-*
gosperma.

covering is formed by the carpels alone; in the plantain, the perianth also enters into the constitution of the pericarp. The pericarp is of a different structure in different fruits: in the tepari it is succulent; in the orange and pomegranate it is externally coriaceous, internally succulent; in many plants of Leguminosæ it is dry and membranous; in the cocoanut it is fibrous on the outside and woody on the inside.

In those plants in which there is a distinction between the consistence of the external, middle, and internal portions, the external portion is called the *epicarp*; the middle layer, the *mesocarp*; and the inner, the *endocarp*. (See Fig. 92r). The distinction between the epicarp, mesocarp, and endocarp arises during the ripening of the fruit; in the immature state they are undistinguishable. In the mango,

Fig. 92b.



Section of a Cotton seed.

Fig. 92c.



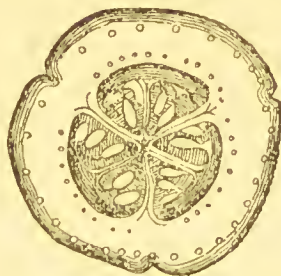
Fruit of *Anacardium occidentale*. The eatable portion is formed from the thalamus, the true fruit resting like a nut on the upper portion.

the epicarp forms the external coat, the mesocarp is succulent, and the endocarp woody. The succulent portion is sometimes called *sarcarp*, and the woody, *putamen*.

During the ripening of the pistil, the ovules which it contains and which have been fertilized are developed into seeds.

Some fruits, particularly the succulent kinds, do not burst to discharge their seeds when ripe; such fruits are called *indehiscent*. Those fruits that burst or separate into pieces when mature, are called *dehiscent*. Fruits may be classified as *mature pistils*, or the classification may be founded on a consideration of their original formation and of their anatomical structure in the early state.

Fig. 92d.



Section of fruit of a eucurbitaceous plant, shewing the peculiar form of parietal placentation.

Fruits classified as mature pistils.

Fruits may be divided into two primary classes—dehiscent and indehiscent.

Dehiscent fruits may be divided into two sub-classes,—

Fig. 92e.

Fig. 92f.



Capsule of *Datura*, shewing the mode of septifragal dehiscence.

Siliqua of *Cruciferae*, shewing the 2 carpels of which the fruit consists dehiscing.

1, capsules, and 2, schizocarps. *Capsules* are dry dehiscent fruits, which burst when ripe and allow the seeds to escape, and include *capsule* proper, *legume*, *follicle*, *siliqua*, and *pyxidium*.

The *capsule* (in the narrower sense of the term) results from a unilocular polycarpellary or a multilocular ovary, and splits longitudinally into two or more lobes or valves, which separate from one another only partially from the apex downwards, or entirely to the base: (a) If the splitting occurs only at the apex, as in *Argemone Mexicana*, the capsule is then said to *dehisce by teeth*. (b) When dehis-

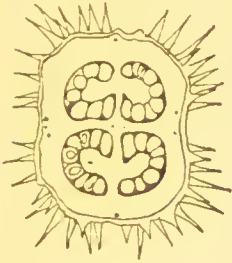
Fig. 92g.



Diagrams showing septifragal, loculicidal, and septicidal Dehiscence.

cence takes place to the base of the capsule, the dehiscence is said to be valvular, of which there are three kinds. If the valves separate from the septa and fall off, as in *Datura*,

Fig. 92h.

Section of fruit of
Datura.

the dehiscence is termed *septifragal* (see Fig. 99); if the septa separate and fall off with the valves, the dehiscence is called *septicidal*; if the walls of the loculi burst open through the dorsal sutures, each valve representing two half-carpels, the dehiscence is named *loculicidal*, as in *Canna Indica*, *Bixa orellana*, and *Lagerstrœmia reginæ*, &c.

(c) In *Papaver* the seeds escape through orifices in the upper part of the walls of

the dry capsule; this form of dehiscence is termed *porous*. The *legume* is a form of capsule consisting of a single carpel which dehisces by both ventral and dorsal sutures, and is the characteristic fruit of *Leguminosæ*. The *follicle* consists also of a single carpel; it differs from the legume in dehiscing by the ventral suture only, as in *Apocynaceæ* and *Asclepiadaceæ*. The *siliqua* consists of two carpels, which form a bilocular fruit with a longitudinal dissepiment; it is also a kind of capsule, and is the characteristic fruit of one group of the

Fig. 92i.

Achenes of
Labiatae.

Fig. 92j.

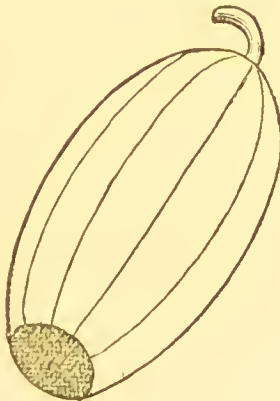
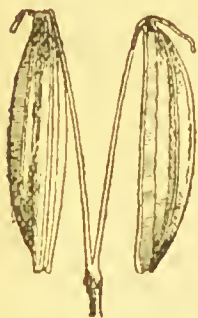
Pyxidium of *Luffa*.

Fig. 92k.

Achene as in *Naravelia Zeylanica*.

Crueiferæ; in another group of the same order the fruit is short and broad; it is then called a *silicula*, the diminutive of *silqua*. The *pyxidium* is a capsule in which the dehiscence takes place transversely, the upper part falling off like a lid from the middle or upper part of the fruit, as in *Portulaca* and *Luffa* (Dúndúl). (See Fig. 92j.)

Fig. 92l.

Cremocarp of *Umbelliferae*.

The *schizocarp*, like the capsule, offers considerable diversity; the term is applied to all fruits that separate when ripe into one-seeded pieces, each piece being indehiscent; in *Labiatae* there are four portions or *cocci*, sometimes called collectively *carcerulus*. In *Umbelliferae* the schizocarp is termed a *cremocarp*, and the indehiscent cocci *mericarps*. In some *Cruciferae* and *Leguminosae*, the schizocarp splits at right angles to the axis; such a fruit is called a *lomentum*.

Indehiscent fruits are simple or confluent. The simple kinds may be divided into *achene*, *berry*, and *drupe*. The *achene* (see Fig. 92k) is a dry indehiscent one-seeded carpel with the seed free in the interior. The *Caryopsis* is the one-seeded fruit

Fig. 92m.

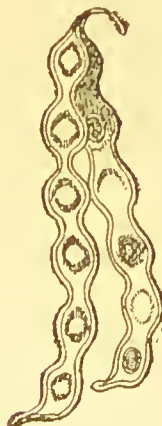
Moniliform
legume of
Acacia.

Fig. 92n.

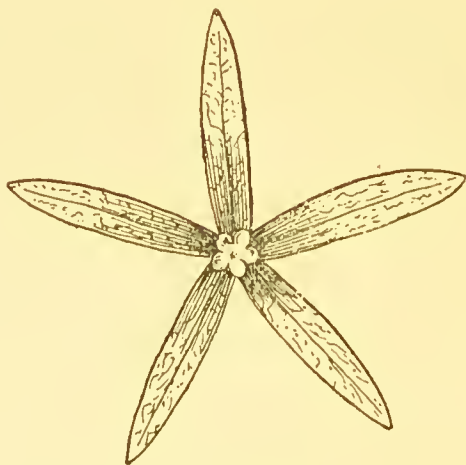
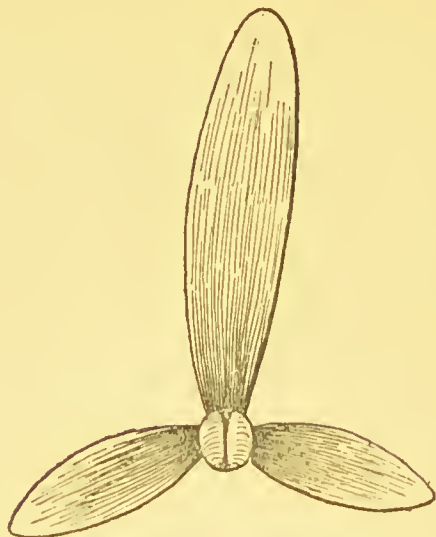
Winged fruit (Samara) of *Petrea volubilis*.
The wings are formed by the persistent
sepals.

Fig. 92o.

Lomentum of *Ormocarpum*.

of the Gramineæ, and differs from achene proper, in the dry pericarp not being separable from the seed. *Cypsela* is the characteristic fruit of the Compositæ; it is an achene often crowned by the pappus, and containing an erect ap-erispermic seed. A *samara* is an achene which has a membranous wing or wings developed from the pericarp, as in *Hiptage*, *Madablota* (see Fig. 92p), &c. The *glans*, originally two or more celled, is a *nut*, the characteristic fruit of the Cupuliferæ with a persistent involucre, called a *cupule*.

Fig. 92p.



Samara of *Hiptage Madublota*; the wings are formed from the carpel during the ripening of the fruit.

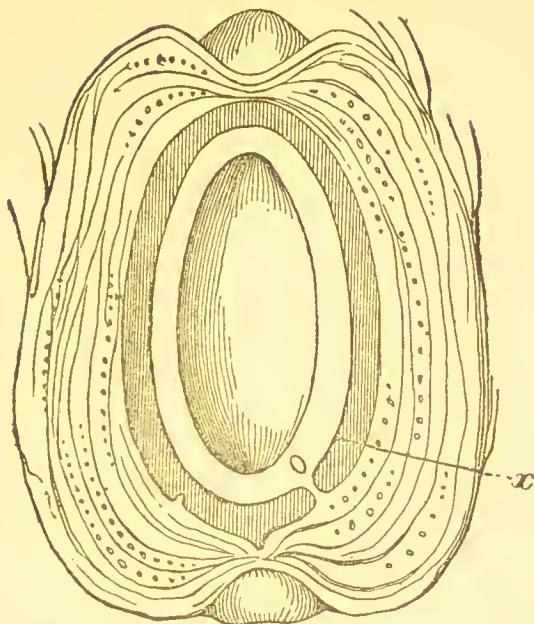
In the following fruits the pericarp is furnished with hooks:—*Martynia diandra* (Cowá), *Pcdallicca* *Achyranthes aspera* (Apáng), *Amarantaceæ Chrysopogon acicularis* (Chorkántá), *Xanthium indicum* (Bon okrá).



Pepo of *Momordica*.

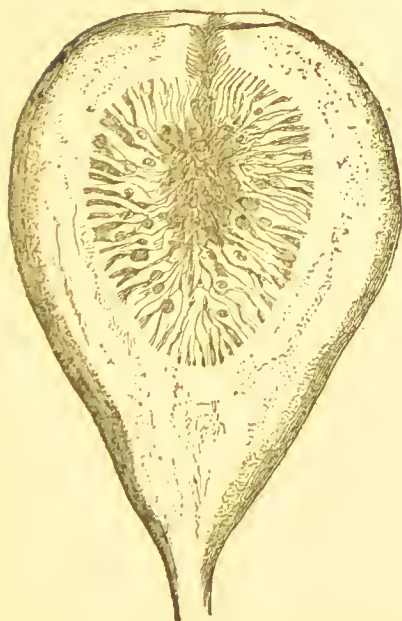
In the berry, all the layers of the pericarp are fleshy and succulent, as in *Physalis peruviana*. The *Pepo* is a berry, with a leathery epicarp, and is the common fruit of *Cucurbitaceæ* (see Figs. 92d and 92q).

Fig. 92r.



Drupaceous fruit of the Coconut. The shell or endocarp (*x*); near the base is seen the minute embryo.

Fig. 92s



Section of the hollow receptacle of the fig; a number of flowers are represented in the hollow portion.

Fig. 92t.



Sorosis of *Ananas sativus*, formed from a succulent axis and cohering berries.

The *drupe* is the ordinary stone fruit, as represented by the mango and cocoanut; the endocarp is hard and woody, and eneloses the seed. The *pome* is a kind of drupe in which the endocarp is cartilaginous, as in the apple.

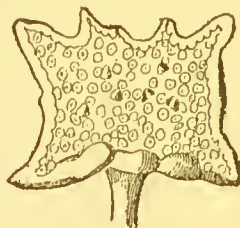
Where the fruits of an inflorescence are massed together, the whole forms a *multiple fruit*, of which there are three kinds. 1st.—The *syconus*, which is a succulent fruit, formed by an enlarged fleshy axis, in which are embedded numerous achenes, as in *Ficus*, &c. 2nd.—The *sorosis*, which is also a succulent fruit, formed by an enlarged fleshy axis, in which are embedded numerous berries, as in pineapple and *Artocarpus*. Sometimes the axis is not succulent, as in *Morus*. 3rd.—*Strobilus*, or cone, is a fruit formed of a conical or ovate mass of imbricated scales. The *galbulus* is a form of strobilus, in which the scales are thickened, forming a globular mass, as in *Thuja*, *Juniper*, &c.

Fig. 92u.



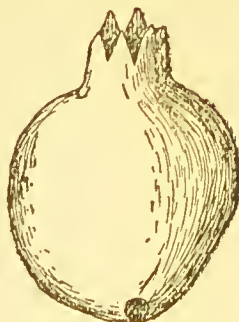
Sorosis of *Morus*,
formed from cohering
berries.

Fig. 92v.

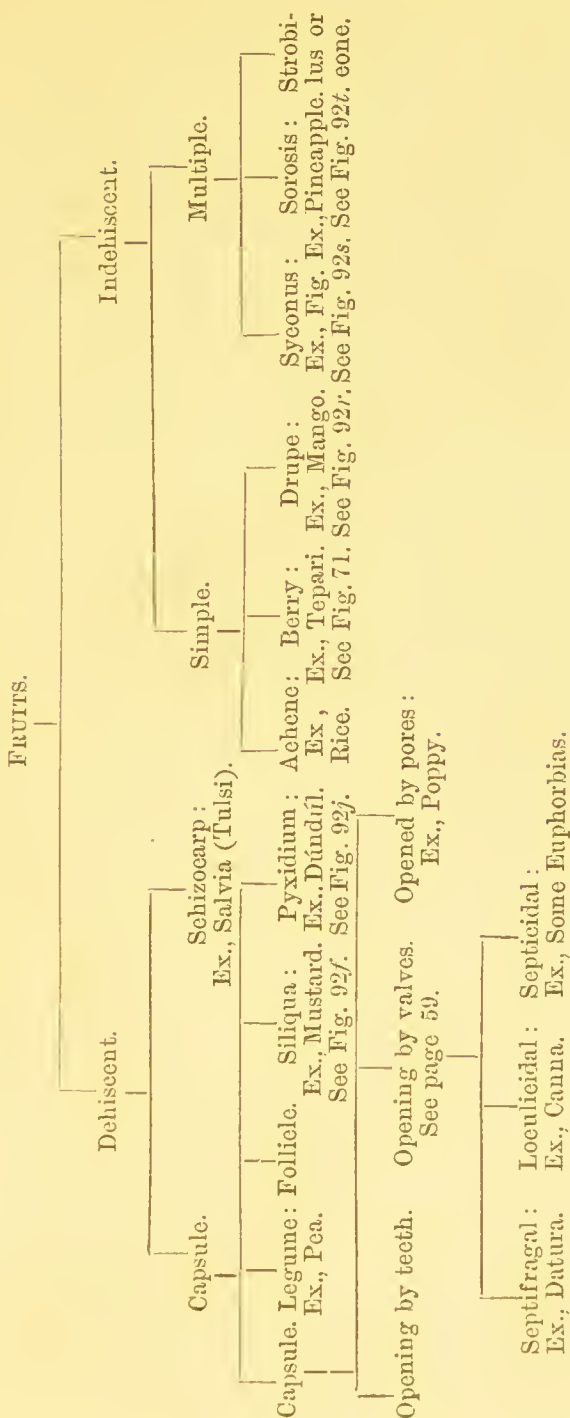


Expanded receptacle of
Dorstenia contrayerva:
each dot represents a
separate fruit imbedded
in the axis.

Fig. 92w.



Paccate fruit of
Pomegranate.

Abstract of fruits classified as mature pistils.

Classification of fruits founded on a consideration of their original formation.

The foregoing classification is probably the simplest, but teaches nothing of the real nature of the fruit. The following, on this account, is recommended by *Sir J. Hooker*. By examining fruits in this way, a better knowledge is obtained of them than by any other means. It is important to observe whether the fruit is the product of an inferior or superior ovary :—

Class I.—*Multiple fruits or Infructescences* (Polythalamie), including (1) syconus, (2) sorosis, (3) strobilus.

Class II.—*Simple fruits formed by the pistil of one flower* (Monothalamie); this class may be divided into six sub-classes :

(a.) *Indehiscent fruits of one carpel*, including the drupe, as in Anacardiaceæ, the achene, as in some Urticaceæ, &c., and some berries.

(b.) *Dehiscent fruits of one carpel*, as the legume of Leguminosæ; in this case the fruit is superior.

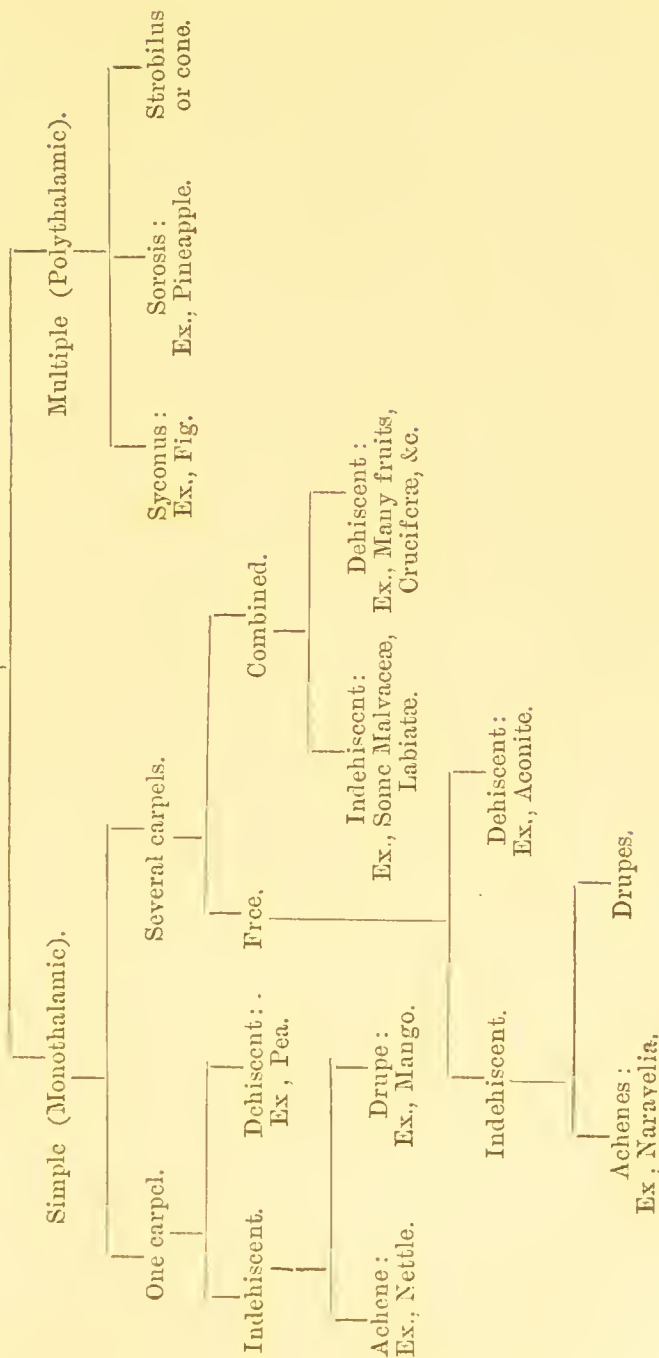
(c.) *Indehiscent fruits of several free carpels*. The carpels may be many, dry (achenes) or succulent (berries).

(d.) *Indehiscent fruits of several combined carpels*. In this sub-class, the fruit may be superior, dry, winged (samara), as in Malpighiaceæ; or superior, consisting of a whorl of cohering achenes, as in some Malvaceæ; or superior formed by four dry lobes from two carpels, as in Labiatæ and Boraginaceæ; or superior, and consisting of a number of drupes on a somewhat fleshy receptacle, as in custardapple; or superior baccate of two combined carpels, as in Solanaceæ; or inferior, consisting of three coherent carpels with central placentas, as in the plantain; or inferior, formed of two achenes, which finally separate, as in Umbelliferæ.

(e.) *Dehiscent fruits of several free carpels*, as in some Ranunculaceæ.

(f.) *Dehiscent fruits of several combined carpels*. In this sub-class, the fruit may be superior, dry, of two carpels, forming a 2-celled capsule, as in Cruciferae; or the fruit may be superior, dry, of three carpels, forming a 1-celled 3-valved capsule, as in Violaceæ; or superior, dry, of two carpels, forming a 2-celled capsule, as in Bixaceæ; or

FRUITS CLASSIFIED ACCORDING TO THEIR ORIGINAL FORMATION.



superior, dry, of many carpels, forming a 1-celled capsule, opening by pores under the stigma, as in Papaveraceæ; or inferior, dry, of three carpels, forming a 1-celled capsule with three valves, which often fall away from a persistent framework, as in Orchideæ.

Eatable portion of fruits.

The sapid and nutritious substances which constitute the pericarp of some fruits are of no direct use for the growth of the seeds, but cause their dissemination by animals which feed on the fruits and thus disperse the seeds. The *eatable portion* varies in different fruits. In *tamarind*, the part eaten is the intercellular tissue of the modified leaf. In the *orange*, *litchi*, and *pomegranate*, the eatable portion is a development from the region of the placenta (arillus); the epicarp, mesocarp, and endocarp are undistinguishable one from the other and form the skin, which is peeled off and thrown away. In the *mango*, the mesocarp is the portion eaten, the epicarp forms the external coat, and the endocarp the stone. In the *papaya* also, the edible portion is the mesocarp. In the *plantain* and *pepo*, the succulently developed carpels are eaten, the persistent perianth forming the skin. In the *guava* the eatable portion is the succulently developed calyx, the fruit being inferior. In the *date*, the epicarp, mesocarp, and endocarp can all be eaten, the seed with an indurated testa forming the stone. In the *cocoanut*, the coir forms the mesocarp, the hard shell is the endocarp, the brown peel outside the white part that is eaten, is the testa, and the white portion is the *endosperm*. The eatable portion of rice is also the endosperm.

The Seed.

The distinguishing feature of the Phanerogamia as contrasted with the Cryptogamia lies in the formation of the seed. This or-

Fig. 92r.



Section of fruit of
Chámpá, shewing the
seeds suspended by long
funiculi.

gan developed from the ovule is an independent reproductive body, containing an embryo, or rudimentary plant at the time when it is cast off by the parent plant. The seed is attached to the placenta, by a more or less strongly developed stalk or *funiculus*, until mature, when it separates by an articulation, leaving a scar, called the *hilum* or umbilicus.

The testa is in general thicker, firmer, and harder in proportion to the softness of the pericarp, especially when this

Fig. 92y.

Reticulated seed of
Poppy, enlarged.

Fig. 92z.

Striated seed of
Tobacco.

latter bursts to allow the dispersion of the seeds. The testa of the seeds of dehiscent fruits is usually covered by a distinctly differentiated epidermis. This latter frequently

exhibits regular markings, as in the poppy (see Fig. 92y), tobacco (see Fig. 92z). The epidermal seeds not unfrequently grow into hairs, as in the *Asclepiadaceæ*; cotton consists of the long hairs which clothe the seed of *Gossypium*: in the *Bignoniaceæ*, *Coniferæ*, and *Moringa pterygospermia* the epidermis of the seeds is developed into wing-like expansions, and serve as an apparatus for the dissemination of the seeds; the inner coat or tegmen is not generally distinguishable; when it is, it is usually white and delicate.

The micropyle is often to be recognized lying in anatropous and campylotropous seeds close beside the hilum generally as a protuberance pitted in the middle. A considerable number of seeds possess an additional covering (*arillus*) distinct from the usual integuments; the *arillus* is a new coat which develops during the ripening of the seed, and envelops it from below, springing from the point of attachment of the seed to the placenta; this additional structure is frequently fleshy when mature, as in the litchi. An *arillode* is a covering of the seed which originates from the micropyle, and grows down, more or less, over the testa, as in *Euphorbia*, *Ricinus*, &c.

The body of the mature seed is composed either of the embryo alone, or of the embryo embedded in a mass of tissue, called the *endosperm*, a substance which contains starch, albuminoids, &c., provided for the nourishment of the embryo; it is usually formed within the embryo-sac (*endosperm*), sometimes in the tissue of the nucleus itself (*perisperm*). This substance is found in more or less quantity in every embryo-sac whilst the embryo is still rudimentary, but it frequently becomes absorbed before the seed is ripe. There is no organic connection whatever between the matured embryo and the endosperm with which it is in contact, yet the embryo, when germinating,

draws nourishing matter from the most distant part of the sperin. Seeds when mature containing endosperm are termed *endospermic*, as the Papaveraceæ, Rubiaceæ, Apocynaceæ. The seeds of Cruciferae, Malvaceæ, Aurantiaceæ, &c., have, when ripe, no endosperm.

Endosperm varies very much both in quantity and in texture; it is *mealy* or *farinaceous* when of a starchy consistence, as in Gramineæ; *oily* in Papaveraceæ; *horny*, or bony, as in Palmaceæ; and *mucilaginous*, swelling up readily when wetted, as in Malvaceæ, &c.; *ruminated*, where the outer portion is lobed and the sinuosities are filled up, and enclosed in an inseparable layer of different coloured tissue, as in Anonaceæ, Myristacaceæ, some Apocynaceæ, and Palmææ.

The embryo exhibits many varieties in the relative position of its parts; in Cruciferae, the cotyledons lie flat one upon another (pleurorhizal), and the radicle upon the line which separates them, or the radicle may be folded against the back of one of the cotyledons (notorhizal), or the radicle may be in the hollow channel of the folded cotyledons (orthoplozie). The embryo may be *straight*, as in Urtiaceæ and Euphorbiaceæ; *curved* in Cannabis Indiae and in Sapindaceæ, in which order the peculiar convolution of the embryo is a very marked character.

The position of the embryo in the endosperm varies in different plants; in Gramineæ and Palmææ, the embryo is *superficial*, or it may be situated in the *centre* of the endosperm, as in Polygonum. Sometimes the embryo is *curved round the outside* of the endosperm, as Mirabilis.

The radicle generally points to the micropyle, rarely away from it.

There are two principal kinds of embryo amongst flowering plants,—the monocotyledonous and dicotyledonous. Both have cotyledons, plumule, and radicle; but they differ most materially in their structure and mode of growth. In Monocotyledons the first leaves produced from the embryo are alternate; the endosperm is usually large, and the embryo small. In Dicotyledons the first leaves of the embryo form a whorl of two (or are opposite); the endosperm is very often rudimentary, often entirely absorbed by the embryo before the ripening of the seeds.

The duration of the vitality of seeds is very variable; the most authentic instance of long-lived seeds is the sacred bean of India, one such taken from a herbarium upwards of one hundred years old having germinated. Wheat is said to retain its vitality for seven years at the longest.

Description of Plants.

In describing a plant, an exact definition of the characters by which it may be recognized should be given. Whether a description is well drawn up or not may be tested by considering whether a person who had never seen the plant could make a drawing of it from the description. In framing descriptions of whatever kind, the order of development must be observed. The description to be complete, must begin with the root and end with the seed.

The following descriptions will serve as examples as to the manner in which plants should be described:—

Sinapis ramosa, Roxb. (Bara-rái).

N. O. Cruciferae.

Cultivated in India, abundantly distributed, cultivated westward to Egypt, and eastward to China.

A tall erect branching annual, rarely glaucous or hispid (at the base only). Lower leaves petioled, sometimes pinnatifid; upper, lanceolate, toothed, subsessile. Flowers bright yellow; pods half inch, linear, lanceolate; beak straight, flattened, half inch; valves with a prominent mid-rib. Seeds small, dark, rugose (from Flora of British India, Hooker, under the name *Brassica juncea*, Hf. and T.)

Glycosmis pentaphylla, D. C. (Ashshaurá).

N. O. Aurantiaceae.

A small evergreen shrub, very common on roadsides and waste places.

Stem erect, from two to four feet in height. Leaves membranous, compound; leaflets (one to five), varying from one to six inches in length, oblong, elliptic, obovate, or lanceolate; margins entire waved. Flowers few or many, small, white, in panicles. Berry white, globose, usually the size of a large pea.

Vinca rosea, L. (Galphiríngí).

N. O. Apocynaceae.

A perennial herb, growing on cultivated ground, with opposite leaves, and axillary red or white flowers.

Root tapering, fibrous; stem erect, woody, branching close to the ground, smooth, of an ash colour; upper portion of branches green. Leaves, simple, opposite, oval, pinnately nerved; apex ending in a fine point; surface smooth, margins entire. Flowers axillary, generally in pairs, regular, hermaphrodite; calyx divided nearly to the base into five lobes, which are acutely pointed; corolla hypocrateriform, much longer than the calyx; tube cylindrical, constricted at the mouth, the spreading limb of five oblique lobes; stamens 5, epipetalous, alternating with the lobes of the corolla; anthers subsessile; pistil syncarpous; the two carpels distinct below, uniting in a single tube above; stigma dumbbell-shaped. Fruit consisting of two foliicles. Seeds numerous, perispermic.

Argemone Mexicana, Linn. (Bara-shelkántá).

N. O. Papaveraceæ.

An herbaceous annual, with yellow juice, prickly leaves, and bright-yellow conspicuous flowers, growing luxuriantly on waste ground.

Root tapering; stem erect, herbaceous, furnished or armed with a few prickles. Leaves simple, sessile, pinnatifid; margins undulated, armed with numerous small prickles; mid-rib and veins white. Flowers solitary terminal; calyx of three sepals, caducous, prickly, valvate in æstivation; corolla of six yellow imbricated petals; stamens indefinite, inserted on the thalamus; pistil syncarpous, 1-celled, ending in a red sessile stigma. Fruit a capsule, like the rest of the plant, prickly, containing numerous black perispermic seeds.

Oryza sativa, L. (Dhán).

N. O. Gramineæ.

(As there are more than a hundred varieties of rice, the description will vary according to the specimen examined.)

A cereal with an erect narrow paniculated inflorescence.

Root fibrous; culm erect, jointed, hollow, striated, glabrous. Leaves alternate, sheathing, linear, finely acuminate, parallel-nerved, scabrous, with minute setæ (bristles, sharp-pointed hairs) directed towards the stem. Ligule prominent, membranous. Inflorescence, a panicle. Spikelets 1-flowered. Outer glumes 2, minute, nearly equal; flowering glumes 2: outer, boat-shaped, scabrous (covered

with very stiff short hairs), embracing the inner glume, 5-nerved, with a minute black mark at the top; inner glume, or palea, resembling in size and appearance the outer glume, boat-shaped, rough, 3-nerved, with a black mark at the top. Lodiculæ 2, small, glabrous; stamens 6, distinct, hypogynous; filaments filaform; anthers versatile, bilocular, dehiscing longitudinally; pistil superior syncarpous, 1-celled, 1-seeded; styles 2, with feathery stigmas. Fruit a caryopsis, enveloped in the adherent persistent glumes; embryo lying at one side at the base of the farinaceous endosperm.

Tamarindus indica, L. (Tintúrí, Amalí).

N. O. Leguminosæ.

One of the commonest and largest trees in India, compact, much branched; the bark is dark coloured; the wood is hard, very durable, and beautifully veined. The leaves are compound, alternate, paripinnate, glabrous; leaflets (from 10 to 20 pairs), subsessile, entire, obtuse; stipules small, caducous. Flowers small in racemes. Bracts obovate, brightly coloured, caducous; calyx gamosepalous, infundibuliform; limb 4-parted, expanding; members imbricated entire; corolla of three petals, one posterior, two lateral, sub-papilionaceous; stamens 3, alternating with staminodes, somewhat monadelphous; anthers oblong, versatile; pistil consisting of one carpel; style short; stigma terminal, obtuse; ovules usually from 8 to 10. Fruit an oblong, usually curved, indehiscent legume; mesocarp and endocarp pulpy enveloping the seeds. Seeds without endosperm, covered by a thick shining testa.

Having got a general idea of the members to be looked to in drawing up a description of a plant, it is desirable to be able to form an estimate of their relative value, to enable the examiner to place the plant in its true natural position. These important characters form the *diagnosis* of a plant or of a group of plants.

The characters given in the following schedules, devised by the late Professor Henslow of Cambridge, are sufficient to determine the orders to which the plants belong. To discriminate the smaller groups of genera and species, recourse must be had to other peculiarities presented by the plants in question:—

Hibiscus rosa-sinensis, L. (Javá).

Organ.	Number.	Isolation.	Arrangement.	Insertion.	Cohesion.	Adhesion.	Form.
Calyx	.....	.....	.....	.....	.....	.....	Regular.
Sepals	5	.....	Verticillate ...	Hypogynous	Gamosepalous	.....	.....
Epicalyx	6	Distinct ...	Verticillate ...	Below sepals	.....	.....	Regular.
Corolla	Polypetalous	.....	.....	.....	.....	.....	.....
Petals	5	Distinct ...	Spiral ...	Hypogynous	.....	Adherent to base of filaments.	Regular.
Stamens	Branched ...	.....	.....	.....	.....	.....	.....
Filaments	.....	.....	Verticillate ...	Hypogynous	Monadelphous	Adhesion to base of petals.	Irregular.
Anthers	1-celled ...	Distinct ...	.....	.....	.....	.....	.....
Carpels	5	.....	Verticillate ...	.....	Syncarpous ...	Superior ...	Regular.
Style	5	.....	.....	.....	Confluent ...	.....	.....
Stigma	5	Distinct ...	.....	.....	.....	.....	Regular.
Ovules or seeds in each carpel.	Indefinite ...	.....	.....	Axial placentation.	.....	.....	.....

Musa paradisíaca, L. (Kaká).

Organ.	Number.	Isolation.	Arrangement.	Insertion.	Cohesion.	Adhesion.	Form.
Perianth ...	.....	.. ...	.....	.....	.....	Superior ...	.....
Phylloues ...	6	.....	Verticillate ...	.....	Gamophyllous	.....	Irregular.
Stamens ...	5	.....	Verticillate ...	.....	.....	.....	Regular.
Filaments ...	5	Distinct ...	.....	Epiphyllous	.....	.....	.....
Anthers ...	2-celled ...	.....	.....	.....	.....	.....	.....
Pistil ...	.....	.....	.....	.....	.....	.....	.....
Carpels ...	3	... ..	Verticillate ...	.....	Syncearpous ...	Inferior ...	Regular style, sometimes folded.
Ovules or seeds in each carpel.	Indefinite ...	.....	.....	Axial placentation.	.....	.....	.....

The Floral Diagram.

Nothing gives such important aid in the study of Flowers as learning to make floral diagrams correctly, and care should be taken to make the diagram sufficiently large; a clear diagram should occupy a space of about 3 inches square; the details which are most important in comparing flowers of different groups should be given. When the number of organs in the flower are small, they can easily be represented as lying on a series of circles, one within the other. A dot above the diagram represents the position of the axis of the flower; different signs have been chosen to represent the number and position of the various separate organs in order to render the explanation more readily visible to the eye. The leaves of the perianth are represented by arcs of a circle; the sign chosen for the stamens resembles a transverse section of an anther; the gynæceum is treated as a simplified transverse section of the ovary, since it is thus most easily distinguished from the other parts.

CHAPTER II.

Classification and Special Morphology.

THE characters of plants are transmitted to their descendants, or, in other words, are hereditary. But, in addition to the inherited properties, new characters may arise in a smaller or larger number of the descendants of a plant which were not possessed by the parent-plants. The characters which arise in single descendants are often only individual, *i. e.*, they are not again transmitted to their descendants. When a new character is transmitted by inheritance to new generations, new constant forms are developed; such new constant forms are termed *varieties*. If the plant were not equal to the calls upon it—if it were unfit for the situation in which it was placed,—it would have become extinct as so many plants have done. The very existence of a plant is the best proof of its organization, being perfect in regard to the functions it has to fulfil, and its adaptation to external influences. If these change to any great degree, it must either change in accordance or cease to exist.

A *species* may be defined as a group of individual plants, which breed together freely and reproduce their like; therefore it follows that all the individuals of a species now living, or which have lived, has descended from a few common ancestors, or, perhaps, from a single pair. The late Mr. Darwin proved, by an overwhelming array of evidence, and a connected chain of irresistible argument, that every group of allied species has descended from a few common ancestors. This is the *origin of species* by descent with modification, or, in other words, by *evolution*. The natural causes by which the change from one species to another was brought about, is termed *natural selection*.

Genera are assemblages of nearly related species, agreeing with one another in general structure and appearance.

The ideas—variety, species, genus—are abstract ideas, and indicate a progressive scale of the difference between individuals, which is small in the variety, larger in the species, and still larger in the genus. It is, therefore, difficult, and to a certain extent impossible, to define what amount of differentiation is necessary in order to classify two different but similar forms as species rather than varieties. “As there is no difference but in degree between a variety and a species, between a species and a genus, between a genus and order, all disputes as to the precise grade to which a group really belongs are vain” (*Balfour*). From experience we learn that a fertile sexual union can not only take place between individuals of the same species, but also between plants which are specifically distinct. A union of this kind is termed *Hybridisation*, and its product a *Hybrid*. According as the union takes place between different varieties of one species, different species of one genus, or between two species belonging to different genera, the resulting hybrid may be termed *variety hybrid*, *species hybrid*, or *genus hybrid*.

Nomenclature.

Nomenclature deals with the naming of plants as members of the vegetable kingdom. Since the time of Linnæus, the primary rule in botanical nomenclature is that every plant shall have a *double name*, compounded of a substantive and an adjective, or a substantive used adjectively, whereof the former indicates the genus, and the latter the species. The names are usually derived from Latin or Greek, the most general languages of science, as they ensure to all plants names which have universal acceptance, and which are equally understood by botanists of all nations. They are moreover more definite and precise in their signification than ordinary vernacular names. Generic names have been, and are still, formed arbitrarily, and without any general recognized principle; a large proportion of modern generic names are formed from words indicating some obvious external peculiarity or some pro-

perty possessed by the plants, as for instance, *Sagittaria*, from their arrow-shaped leaves; *Rubia*, from the plants yielding a red dye. Generic names are sometimes also founded on proper names of persons to whom the genera are dedicated. Mr. C. B. Clarke lately named a new genus of the Cucurbitaceæ, *Edgaria*, from Mr. Edgar, Commissioner of Patna. Specific names are usually selected on similar grounds to the generic ones, and when they are adjectives, must of course be made to agree in gender with their generic substantives. Since the conception of a genus and of a species is defined arbitrarily according to the individual view of each botanist, it has come to pass in the course of time, that one and the same plant has received several specific and generic names, or that the same name has been given to different plants. In order to distinguish clearly the particular plant meant, it is usual to append to its name, the name of the botanist who first described it, or referred it to the genus in question: thus for instance, *Opuntia Dillenii*, Haworth, and *Cactus indicus*, Roxburgh, is one and the same plant described by Roxburgh in his *Flora Indica*, 2, p. 475. *Calotropis gigantea*, Robert Brown, is described in Roxburgh's *Flora Indica*, 2, p. 30, under the name *Aselepias gigantea*.

For the purpose of obtaining a general view of the enormous number of plants, and their relationships to one another, it is necessary to group the allied genera into *families* or *orders*, and the orders agreeing in evident and important general characters into *classes*; several classes form a *sub-kingdom*, and the group of sub-kingdoms constitutes the *vegetable kingdom*.

Systems of Classification.

"There are two systems pursued in the arrangement of plants; one is called the *Artificial* method, and the other the *Natural* method. In both of them the genera and species, or the minor divisions, are the same, but the higher divisions of classes and orders are totally unlike, and are founded on entirely different principles. The genera and species are very differently arranged in the two systems. In artificial methods one or two organs are selected in an arbitrary manner, and they are taken as the

means of forming classes and orders; while in the natural method plants are grouped according to their alliance in all their important characters. Plants belonging to the same class and order in the former system may have nothing in common except the number of the stamens and carpels, or the form of their flowers, or some other arbitrarily selected character; while in the latter, plants in the same class and order are related by true affinity, and correspond in all the essential points of their structure and organization. When a student knows the artificial class and order to which a plant is to be referred, he does not thereby become acquainted with its structure and properties; plants diametrically opposed in these respects may be associated together. When he determines, on the other hand, the place of a plant in the natural system, he necessarily acquires a knowledge of its structural relations and affinities. Hence a knowledge of the latter system is that which must be the aim of every botanical student" (*Balfour*).

Many artificial systems were in vogue at different times, but the best was the sexual system of Linnæus, which bases its principle of classification on the essential or sexual organs of plants; for this reason his system is called the *sexual system*. Roxburgh's *Flora Indica*, the best complete book on the description of Indian plants, is arranged in accordance with the Linnæan System.

The Linnæan System.

In the artificial system of Linnæus, plants are divided into flowering and flowerless, the latter being included in his twenty-fourth class, under the name of *Cryptogamia*, and the former, or *Phanerogamia*, being divided into twenty-three classes, the characters of which are founded on the number, the insertion or position, the relative length, and the connection of the stamens. The term *andria* is employed to express the male organ or stamen; the number of stamens is indicated by the Greek numerals being prefixed to the term andria.

In the first eleven classes, the number of *free* stamens forms the basis of classification; the length of the stamens is immaterial, excepting the 4th and 6th classes, in which

they must be all of equal length; the 12th and 13th classes have both indefinite stamens, but the mode of their insertion is taken into account; in the 14th and 15th, the number and unequal length of the stamens forms the distinction; in the 16th, 17th, 18th, and 19th classes, Linnæus included those plants in which the stamens are coherent; in the 20th, those in which the stamens are adherent to the pistil; the 21st, 22nd, and 23rd classes include plants with unisexual flowers. Each of these classes comprise several orders; in the first thirteen classes, the character of the order depends on the number of carpels, or on the number of styles and stigmas; the term *gynia* is applied to them (meaning female or pistil) with the prefix of a Greek numeral, as Monogynia, Digynia, &c.; the 14th and 15th classes have each two orders distinguished by the character of their fruit; the orders in the 16th, 17th, and 18th classes are distinguished by the form of cohesion of the stamens; the 19th class is divided into five orders according to the sex of the florets contained in the same capitulum; in the 20th, 21st, 22nd, and 23rd classes, the orders are formed according to the number and position of the stamens; the 24th class Linnæus divided according to their natural relationship into four orders:—1st, ferns; 2nd, mosses; 3rd, algæ; 4th, fungi.

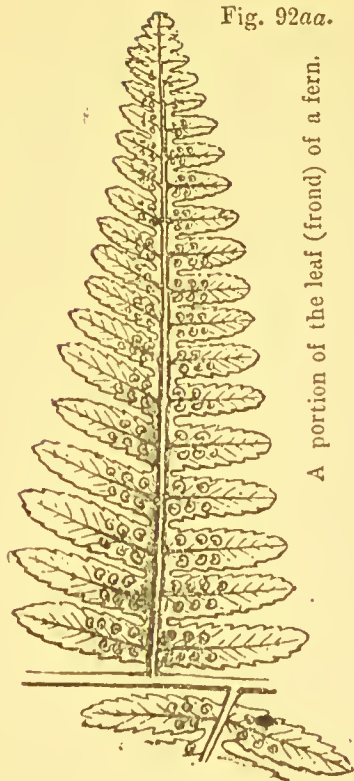
Linnean Classes.

- 1st Class.—*Monandria*: one free stamen in a hermaphrodite flower, as in Marantaceæ and Zingiberaceæ (in Marantaceæ, the stamen is lateral; in Zingiberaceæ, posterior).
- 2nd Class.—*Diandria*: two free stamens in a hermaphrodite flower, as in Jasminaceæ, some Acanthaceæ (*Eranthemum* and *Justicia*), and a few Piperaceæ.
- 3rd Class.—*Triandria*: three free stamens in a hermaphrodite flower, as in most Gramineæ, Cypereæ.
- 4th Class.—*Tetrandria*: four free stamens of equal length in a hermaphrodite flower, as in some Rubiaceæ, Gentianaceæ, Ampelideæ, Onagraceæ.
- 5th Class.—*Pentandria*: five free stamens in a hermaphrodite flower, as in Convolvulaceæ, Solanaceæ, Apocynaceæ, Linaceæ.

- 6th Class.—*Hexandria* : six free stamens of equal length in a hermaphrodite flower, as in *Bambusa*, *Oryza*, in *Amaryllidaceæ*, *Liliaceæ*, *Palmeæ*, &c.
- 7th Class.—*Heptandria* : seven free stamens in a hermaphrodite flower, as in *Saraca indica* (Ashak).
- 8th Class.—*Octandria* : eight free stamens in a hermaphrodite flower, as in *Mimusops elengi* (Bokul), *Lawsonia* (Mendi), *Cardiospermum halicacabum* (Shibjhool).
- 9th Class.—*Enneandria* : nine free stamens in a hermaphrodite flower, as in the *Lauraceæ* (*Cassyta*, *Akash balli*), *Anacardium occidentale* (Hijili bádám).
- 10th Class.—*Decandria* : ten free stamens in a hermaphrodite flower, as in *Cæsalpiniciæ* (*Poinciana pulcherrima*, *Krishnachúra*), *Oxalidaceæ* (*Oxalis corniculata*, *Amrool*), *Combretaceæ* (*Terminalia catappa*, *Badám*).
- 11th Class.—*Dodecandria* : twelve to nineteen free stamens in a hermaphrodite flower, as in *Portulaca*, *Euphorbia*.
- 12th Class.—*Icosandria* : twenty or more free stamens inserted on the calyx of a hermaphrodite flower, as in *Cactus*, in *Myrtaceæ* (*Psidium*, *Guava*), *Rosaceæ*.
- 13th Class.—*Polyandria* : twenty or more free stamens inserted on the receptacle of a hermaphrodite flower, as in *Mimoseæ*, *Nymphæaceæ*, *Anonaceæ*, *Papaveraceæ*, &c.
- 14th Class.—*Didynamia* (superiority of two) : two long and two short free stamens in a hermaphrodite flower.
 Order I—*Gynnospermia* (naked seeded), as in *Labiataæ* and *Boraginaceæ*.
 Order II—*Angiospermia* (covered seeded), as in *Acanthaceæ*, *Verbenaceæ*, *Orobanchaceæ*, *Scrophulariaceæ*, *Pedaliaceæ*, &c.
- 15th Class.—*Tetradynamia* (superiority of four) : four long and two short free stamens in a hermaphrodite flower.
 Order I—*Siliculosæ* : Ex., *Candytuft*.
 Order II—*Siliquosæ* : Ex., *Mustard*.
- 16th Class.—*Monadelphía* (single brotherhood) : stamens coherent into a tube in a hermaphrodite flower, as in *Malvaceæ*, *Sterculiaceæ*, *Meliaceæ*, &c.
- 17th Class.—*Diadelphía* (two brotherhoods) : stamens coherent into two bundles in a hermaphrodite flower, as in many *Leguminosæ*.

- 18th Class.—*Polyadelphia* (many brotherhoods): stamens coherent into three or more bundles in a hermaphrodite flower, as in *Aurantiaceæ*, *Hypericaceæ*.
- 19th Class.—*Syngenesia* (growing together), *polygamia*: anthers coherent, flowers inserted on a capitulum.
- Order I—*Polygamia æqualis* (flowers all equal). All the florets perfect, and of the same shape. Example: *Vernonia* (Koksim).
- Order II—*Polygamia superflua* (some flowers superfluous). Disk-florets perfect; ray-florets pistillate; all forming seed. Example: *Zinnia Crysanthemum*.
- Order III—*Polygamia frustranea* (some flowers neuter). Like the last, except that the ray-florets are barren. Example: *Centaurea Helianthus*.
- Order IV—*Polygamia necessaria* (central and marginal flowers necessary for perfect seed). Disk-florets staminate; ray-florets pistillate. Example: *Calendula* (Gándá).
- Order V—*Polygamia segregata* (flowers separated). Florets perfect, each floret with an additional calyx, or involucre. Example: *Echinops* (Hincha).
- 20th Class.—*Gynandria* (male and female organs): one or more stamens adherent to the pistil, as in *Orchideæ*.
- 21st Class.—*Monœcia* (living together): flowers unisexual, staminate, and pistillate flowers on the same plant, as in many *Aroideæ*, *Artocarpaceæ* (*Ficus*), *Euphorbiaceæ*, and many *Cucurbitaceæ*, &c.
- 22nd Class.—*Diœcia* (living apart): flowers unisexual, staminate, and pistillate flowers on distinct plants, as in *Vallisneria*, *Cannabis sativa*, *Carica Papaya*, *Trewia nudiflora*, *Borassus flabelliformis*, &c.
- 23rd Class.—*Polygamia* (many marriages): staminate, pistillate, and hermaphrodite flowers, on the same plant, as in *Semecarpus anacardium*.
- 24th Class.—*Flowerless plants*:
- Order I—*Ferns* (see Fig. 92aa).
- Order II—*Mosses* (see Fig. 92bb).
- Order III—*Algæ* (see Fig. 92cc).
- Order IV—*Fungi* including lichens (see Figs. 92dd and 92ee).

Fig. 92aa.



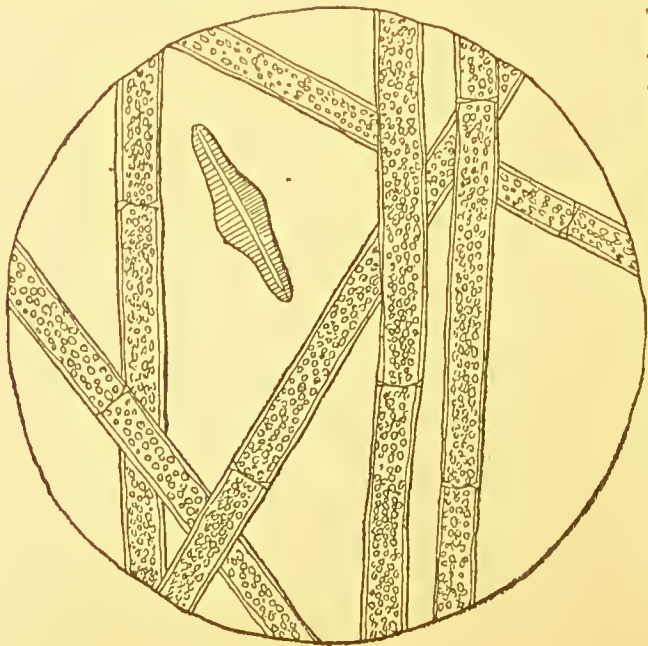
A portion of the leaf (frond) of a fern.

Fig. 92bb.



A moss (*Hypnum*) shewing the leafy portion (sexual generation) and fruit-like structure (a sexual generation) in which the spores are formed.

Fig. 92cc.



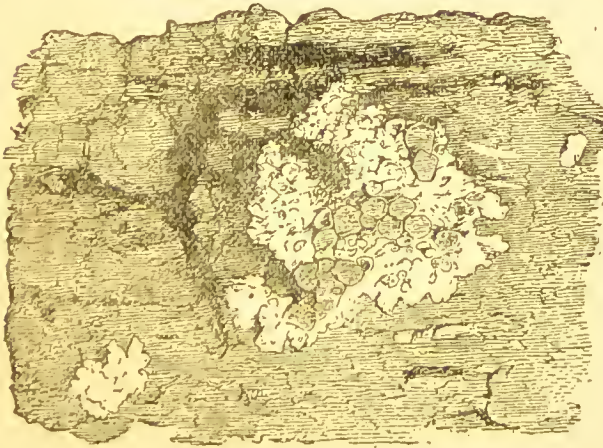
A common filamentous Alga (*Cedogonium*) found abundantly in fresh water tanks; also a unicellular Alga (*Diatome*).

Fig. 92dd.



A fungus (Mushroom): the root-like structure is termed mycelium; the stem and cap form the sexual generation.

Fig. 92ee.



A lichen (*Parmelia*) with a portion of the bark of the tree from which it was taken; in the hollow cup-like structures are formed the spores.

The term *Gymnospermia*, used in the 14th class, was founded on the erroneous idea that the fruit of *Labiata*, &c., which are in reality achenes, were naked seeds.

The Natural System.

In arranging plants according to the *natural system*, the object is to bring together those which are allied in all essential points of structure.

The system of Jussieu, is now the basis of all natural classifications. The system followed by De Candolle is a modification of that of Jussieu, and it is adopted more or less at the present day. Since De Candolle's time, various modifications of his system have been introduced by Endlicher, Lindley, Bentham, and Hooker. According to this classification, the vegetable kingdom is divided into two great sub-kingdoms—*Phanerogamia* and *Cryptogamia*; the former having flowers containing anthers and ovules, the latter being destitute of them. *Phanerogamia* are divided into: 1st, *Angiospermia* (seeds covered); 2nd, *Gymnospermia* (seeds naked). The *Angiospermia* are distinguished from the *Gymnospermia* by the following characters: 1st—the ovules are produced in the interior of a structure (*ovary*) formed by the cohesion of carpellary leaves; 2nd—the endosperm is formed after fertilization at the same time as the embryo; 3rd—the contents of the pollen grains do not divide. In the *Gymnospermia*, on the other hand,—1st, the ovules are not enclosed in an ovary; 2nd, the endosperm arises before fertilization; and 3rd, the pollen grains are divided before the formation of the pollen tube. *Angiosperms* are again divided into two classes—*Dicotyledons* and *Monocotyledons*.

The following abstract shows at a glance the positions occupied by the principal groups of plants in the vegetable kingdom:—

VEGETABLE KINGDOM.	{	Phanerogamia (flowering plant).	{	Angiospermia	{	Dicotyledons: Ex., Mangoe-trees.
					{	Monocotyledons: Ex., Palm-trees.
				{	Gymnospermia	Ex., Coniferae, Pine-trees.
						Filicinæ: Ex., Ferns.
	{	Cryptogamia (non-flowering plant).	{	Vascular Cryptogams.	{	Equisetacea: Ex., Horse-tails.
						Dichotomi: Ex., Club Mosses.
						Mosses: Liverworts.
			{	Thallophyta ...	{	Algae: Ex., Seaweeds.
						Fungi: Ex., Mushrooms and Lichens.

Dicotyledons.

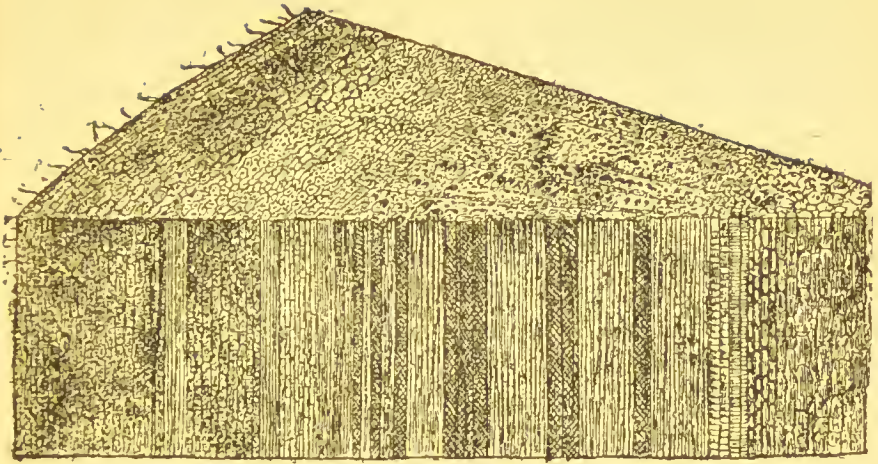
In dicotyledons, the first leaves of the embryo form a whorl of two (or are opposite); the endosperm is very often rudimentary, often entirely absorbed by the rapid growth of the embryo before the ripening of the seed. Instead of the two opposite cotyledons, a whorl of three is not unfrequently formed in those plants which normally possess only two, as *Phaseolus*, *Amygdalus*. The opposite cotyledons are usually alike in form and vigour; in *Trapa*, however, one remains much smaller than the other. Most often the cotyledons lie with their inner faces flat against one another, but are not unfrequently folded or wrinkled, and curved backwards and forwards, as in *Convolvulaceæ*; less often they are rolled spirally round one another.

The cotyledons which become exposed to the light usually increase rapidly in size, and constitute the first foliage leaves of the plant, which are of simple form as in *Cucurbitaceæ*, *Convolvulaceæ*, &c. The further development of the young plant may take place by the rapid enlargement of the primary axis of the embryo. When the axis of the embryo grows vigorously, the primary root generally also grows vigorously in a downward direction. In its internal structure the roots of dicotyledons have at first the same structure and arrangement of their elements as the monocotyledons. A great difference, however, shows itself in the secondary formations, which enable the roots to thicken and even to form concentric circles somewhat in the manner of the stem, the only difference being that the vascular bundles of the stem have a centrifugal growth; while development of those in the root are centripetal. On this account the pith is less developed in the root than in the stem, and in many roots it entirely disappears.

The structure of the *stem* of dicotyledons agrees in its main feature with that of the *Gymnospermia*, a class of a lower type of organization, but differs very considerably from the arrangement of the stems of monocotyledons.

The whole of the tissue of dicotyledonous (i common with other vascular) plants is differentiated into the clearly

Fig. 92ff.



Section of a Dicotyledonous stem, shewing the Epidermal tissue, Fibro-vascular bundles, and Fundamental tissue.

marked systems,—*viz.*, the epidermal system, the fundamental system, and the fibro-vascular system.

When a young dicotyledonous herbaceous stem, as for instance, *Cucurbita maxima*, is cut across, the fibro-vascular bundles are seen standing in a circle round a central mass of tissue, the *pith*. The bundles run parallel to the axis of the stem, and anastomose freely; a certain number of the bundles are distributed to each leaf.

The plates of fundamental tissue which lie between the fibro-vascular bundles, connecting the pith with the epidermal system, are termed the *medullary rays*.

Usually, in annual stems, and invariably in woody stems, a further increase of thickness takes place through the activity of the growing (or *cambium*) layer, situated between the inner and outer portion of the fibro-vascular bundles. The cambium region in wood of more than one year's growth is a continuous mass of tissue surrounding the inner (woody) part of all the bundles; while the inner layer of cortex, next to the cambium, is that portion which belongs to the same year's formation as the outermost of the woody rings.

When the increase in thickness of a stem ceases periodically, and is renewed with each new period of vegeta-

Fig. 92gg.



Section of a Dicotyledonous stem, shewing the annual rings of the wood.

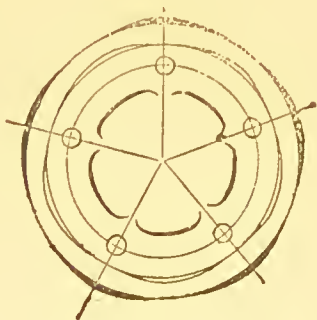
tion, a layer of wood is formed during each period of growth, which is more or less sharply marked off from that of the preceding and of the following year, and is called an annual ring of the wood (see Fig. 92gg). These annual rings are usually distinctly visible to the naked eye, because the mass of wood formed in the early

part of each period of vegetation has usually a different appearance from that formed at a later period.

The leaves of dicotyledons exhibit a greater variety, both in their position and form, than those of all other classes put together. The venation of the foliage leaves is formed by the ramification and anastomosis of the fibro-vascular bundles running through the fundamental tissue of the leaf itself. Adventitious buds are rare in dicotyledons, as they are in the Phanerogamia generally; those which are commonly formed in the indentations of the margins of the leaves of *Bryophyllum calycinum* are well-known, and serve to propagate the plant.

In the great majority of dicotyledons the members of the

Fig. 92hh.



Floral diagram of a dicotyledonous flower, shewing the 4 whorls of organs.

flower are arranged in whorls, which are generally four in number—calyx, corolla, androecium, and gynæceum (see Fig. 92hh); only in a comparatively small number of families are the floral leaves arranged spirally, as *Ranunculaceæ*, *Magnoliaceæ*, *Nymphæaceæ*, and *Nelumbiaceæ*. The flowers are usually pentamerous, less often tetramerous. Dimerous combinations, as in some *Onagraceæ*,

and trimerous, as in *Anonaceæ*, *Menispermaceæ*, *Magnoliaceæ*, and *Aristolochiaceæ*, are much less common.

Abstract of the Principal Dicotyledonous Cohorts.

DICOTYLEDONS.	{ Apopetalæ (Polypetalæ).	{ Thalamifloræ ...	{ Ranales : Ex., Naravelia.
			{ Parietales : Ex., Poppy.
		{ Disifloræ ...	{ Polygalales : Ex., Polygala.
			{ Caryophyllales : Ex., Portulaca.
		{ Calycifloræ ...	{ Guttiferales : Ex., Tea.
			{ Malvales : Ex., Hibiscus.
	{ Gamopetalæ ...	{ Inferæ ...	{ Rosales : Ex., Rose.
			{ Myrtales : Ex., Guava.
		{ Superæ ...	{ Passiflorales : Ex., Melon.
			{ Ticoidales : Ex., Caetus.
		{ Inferæ ...	{ Umbellales : Ex., Panax.
			{ Rubrales : Ex., Ixora.
		{ Superæ ...	{ Asterales : Ex., Zinnia.
			{ Campanulales : Ex., Lobelia.
		{ Inferæ ...	{ Ericales : Ex., Rhododendron.
			{ Primulales : Ex., Plumbago.
		{ Superæ ...	{ Ebenales : Ex., Sapota.
			{ Gentianales : Ex., Vinca.
	{ Inferæ ...	{ Polemoniaceales : Ex., Potato.	
		{ Lamiales : Ex., Tulsi.	
{ Superæ ...	{ Personales : Ex., Bignonia.		
	{ Inferæ ...	{ Santalales : Ex., Loranthus.	
{ Superæ ...		{ Quernales : Ex., Oak.	
	{ Inferæ ...	{ Asarales : Ex., Aristolochia.	
{ Superæ ...		{ Piperales : Ex., Betel.	
	{ Inferæ ...	{ Euphorbiales : Ex., Coral plant.	
{ Superæ ...		{ Amentales : Ex., Casuarina.	
	{ Inferæ ...	{ Urticales : Ex., Jack-tree.	
{ Superæ ...		{ Daphniales : Ex., Grevillea.	
	{ Inferæ ...	{ Laurales : Ex., Camphor-tree.	
{ Superæ ...		{ Chenopodiales : Ex., Mirabilis.	

ABSTRACT OF DICOTYLEDONOUS ORDERS.

DIVISION I—*Apopetalæ* (*Polypetalæ*).

Petals free or very slightly united.

Series I—THALAMIFLORÆ.

Calyx, corolla, and stamens usually free, and springing directly from the thalamus; pistil superior.

Cohort I—*Ranules*.

Stamens indefinite (except in Menispermaceæ and Berberidaceæ); carpels free or immersed in the receptacle, very rarely syncarpous (as in some Dilleniaceæ, Nymphæaceæ, and Anona); micropyle, usually inferior; embryo minute, in a fleshy endosperm or perisperm.

Order I, Ranunculaceæ.—Herbs with alternate or climbing shrubs, with opposite leaves, with mostly alternate exstipulate leaves and aerid juice; stamens indefinite; ovules anatropous; fruit a collection of achenes, a circle of foliicles, or a one or more seeded berry; seed exarillate; embryo straight. Example: *Naravelia zeylanica* (Chhāgal-bātī).

Order II, Dilleniaceæ.—Trees or shrubs, generally with alternate leathery feather-veined leaves; calyx persistent, 5-merous, imbricated; seeds arillate. Example: *Dillenia speciosa* (Chālītā).

Order III, Magnoliaceæ.—Trees or shrubs, with fragrant 3-merous imbricated flowers; the leaf-buds mostly with membranous stipules; seeds often suspended by a long funiculus, endosperm homogeneous. Example: *Michelia champaea* (Chāmpā).

Order IV, Anonaceæ.—Trees or shrubs, with alternate entire exstipulate leaves; flowers trimerous; corolla usually valvate in the bud; stamens with enlarged connective, endosperm ruminated. Example: *Anona squamosa* (Atā).

Order V, Menispermaceæ.—Climbing shrubs, with alternate exstipulate leaves, and usually dioecious trimerous flowers; stamens definite, superposed to the petals; fruit of three to many 1-seeded drupes. Example: *Tinospora cordifolia* (Gulaeha).

Order VI, Berberidaceæ.—Shrubs or herbs, with stamens superposed to the petals; anthers opening by valves.

Order VII, Nymphæaceæ.—Aquatic plants with cordate or peltate floating leaves, and large conspicuous flowers; the partially petaloid sepals and numerous petals, and stamens imbricated in several rows; pistil syncarpous. Example: *Nymphæa lotus*.

Order VIII, Nelumbiaceæ.—Large aquatic plants, with peltate leaves, raised above the water, on long stalks; stamens indefinite; carpels, embedded in separate cavities of the enlarged thalamus; seeds with endosperm. Example: *Nelumbium speciosum* (Padma).

Cohort II—*Parietales*.

Stamens definite or indefinite, carpels usually united into a unilocular ovary, with parietal placentation.

Order I, Papaveraceæ.—Herbs with milky juice; alternate exstipulate leaves and regular flowers; sepals caducous; stamens indefinite. Example: *Papaver somniferum*.

Order II, Fumariaceæ.—Herbs with watery juice; flowers irregular; sepals 2, caducous; petals 4, dissimilar; six diadelphous, or four distinct stamens. Example: *Fumaria parviflora* (Banshalphá).

Order III, Cruciferae.—Herbs with a pungent watery juice; petals 4; stamens tetradynamous; fruit a siliqua, or silicula; seeds without endosperm. Example: *Raphanus sativus* (Múlá).

Order IV, Capparidaceæ.—Herbs, shrubs, or trees, with alternate leaves; sepals and petals usually 4; stamens indefinite, or, if six, not tetradynamous; ovary usually stalked; seeds reniform, without endosperm. Example: *Gynandropsis pentaphylla* (Kánálá).

Order V, Resedaceæ.—Herbaceous plants, with alternate leaves and unsymmetrical racemose or spiked flowers; stamens definite, inserted on a fleshy one-sided disk; fruit usually 1-celled, opening at the top before the seeds are ripe. Example: *Mignonette*.

Order VI, Bixaceæ.—Trees or shrubs, with alternate simple leaves and hermaphrodite or unisexual flowers; stamens indefinite; ovary usually 1-celled; seeds numerous, endospermic. Example: *Bixa Orellana* (Latkan).

Order VII, Violaceae.—Herbs or shrubs, with alternate, usually stipulate, leaves, and irregular hermaphrodite flowers; sepals, petals, and stamens 5; the connective of the anther usually prolonged; ovary 1-celled, with three parietal placentas; seeds endospermic. Example: Violet.

Order VIII, Moringaceae.—Trees with alternate compound stipulate leaves and irregular flowers; stamens arising from a perigynous disk; the 1-celled capsular fruit pod-like, with three parietal placentas. Example: *Moringa pterygosperma* (Sujina).

Cohort III—*Polygalales*.

Plants with exstipulate leaves; flowers regular or irregular; calyx imbricated; sepals and petals usually 5; stamens as many, or twice as many, as the petals; ovary usually 2-celled; endosperm fleshy.

Order I, Polygalaceae.—Herbs, shrubs, or trees, with alternate simple exstipulate leaves and irregular hermaphrodite flowers; stamens 4 to 8, diadelphous or monadelphous; anthers opening by pores. Example: *Polygala arvensis* (Merádú).

Cohort IV—*Caryophyllales*.

Flowers regular; calyx imbricated; sepals and petals 2 to 5, rarely 6; stamens usually as many or twice as many; ovary 1-celled, with generally free central placentation; ovules campylotropous; embryo curved in a floury endosperm.

Order I, Caryophyllaceae.—Herbs with opposite entire leaves, stems swollen at the joint; flowers symmetrical, 4 to 5-merous; stamens definite; ovary 1-celled, with a free central placenta; embryo curved round the mealy endosperm. Example: *Dianthus chinensis* (Pink).

Order II, Portulacaceae.—Succulent herbs; sepals 2; petals mostly 5; stamens generally indefinite; capsule 1-celled, with a free central placenta; embryo curved round the mealy endosperm. Example: *Portulaca meridiana* (Luniya).

Order III, Tamaricaceae.—Trees or shrubs, with alternate scale like leaves and flowers, in close spikes or

racemes; calyx 4 to 5-parted, persistent; stamens definite; capsule 3-valved, 1-celled, with central placentation. Example: *Tamarix Indica* (Jhau).

Cohort V—*Guttiferales*.

Trees or shrubs, rarely herbs; flowers regular; sepals and petals usually 4 to 5, imbricated in the bud; stamens generally indefinite; ovary one to many celled, with central placentation.

Order I, Guttiferae.—Trees or shrubs with resinous juice, and opposite leathery leaves; flowers unisexual or polygamous; sepals imbricated, in two or more decussating pairs; stamens often indefinite; ovary superior, one to many celled; stigmas sessile; seeds without endosperm. Example: *Calophyllum Inophyllum* (Súltáná chám pá).

Order II, Hypericaceae.—Herbs or shrubs, with opposite entire dotted leaves; flowers hermaphrodite; stamens polyadelphous; fruit, a capsule with septicidal dehiscence; seeds numerous, without endosperm. Example: *Hypericum chinense*.

Order III, Dipteraceae.—Large trees abounding in resinous juice, with alternate, penni-nerved, stipulate leaves; calyx 5-lobed, imbricated, unequal, persistent; fruit 1-celled, surrounded by the enlarged calyx, which forms winged appendages. Example: *Shorea robusta* (Sál).

Order IV, Ternstræmiaceae.—Trees or shrubs, with alternate, leathery, simple, exstipulate leaves; flowers hermaphrodite, rarely unisexual; stamens indefinite; ovary many celled; seeds few, sometimes arillate; endosperm little or none. Example: *Thea chinensis* (Tea).

Cohort VI—*Malvales*.

Plants with alternate, usually stipulate, leaves; flowers mostly regular; calyx valvate; sepals and petals 5, rarely 2 to 4; ovary two or many celled, with central placentation.

Order I, Malvaceae.—Herbs or shrubs, with alternate stipulate leaves and regular flowers; calyx valate, and corolla convolute in æstivation; stamens numerous, monadelphous, with 1-celled anthers. Example: *Hibiscus rosa-sinensis* (Javá).

Order II, Sterculiaceæ.—Trees, shrubs, or herbs, with alternate simple or compound leaves, and free deciduous stipules; calyx valvate; stamens monadelphous, with 2-celled anthers. Example: *Sterculia foetida* (Janglí-bádám).

Order III, Tiliaceæ.—Trees, shrubs, or herbs, with usually alternate simple stipulate leaves and regular flowers; calyx valvate; stamens indefinite, free or very slightly united with 2-celled anthers. Example: *Corchorus olitorius* (Pát).

Series II—DISCIFLORÆ.

Sepals distinct or united; petals distinct; disk conspicuous, free or adnate; stamens usually definite, inserted within, upon, or at the edge of the disk; ovary superior.

Cohort I—*Geraniales*.

Flowers generally irregular, with an annular disk; ovary multicarpellary, syncarpous, with one or two, rarely more, ovules in each carpel; radicle superior.

Order I, Geraniaceæ.—Herbs or shrubs, with articulated swollen joints and membranous stipules; leaves aromatic; flowers 5-merous; stamens mostly 10; carpels 5, supported on a carpophore, from which they separate, when ripe, by the elastic segments of the style. Example: *Pelargonium*.

Order II, Linaceæ.—Herbs or shrubs, with simple alternate undivided leaves without stipules; flowers mostly 5-merous throughout; calyx imbricated; stamens coherent at the base; styles distinct; capsule many celled, each loculus divided by a false septum from the dorsal suture. Example: *Linum usitatissimum* (Tisi).

Order III, Oxalidaceæ.—Herbs, rarely shrubs, with alternate compound leaves and regular symmetrical 5-merous flowers; stamens 10, somewhat monadelphous; styles distinct; calyx imbricated; corolla convolute. Example: *Oxalis corniculata* (Amrúl).

Order IV, Malpighiaceæ.—Climbing shrubs, with opposite entire stipulate leaves; calyx glandular; petals clawed; stamens mostly 10; carpels usually 3, often winged; ovules solitary, pendulous; seeds without endosperm. Example: *Hiptage Madablota*.

Order V, Zygophyllaceæ.—Herbs or shrubs, with opposite stipulate compound leaves; flowers on axillary peduncles;

stamens free, 8 to 10, often with a scale at the base. Example: *Tribulus terrestris* (Gokhur).

Order VI, Rutaceæ.—Usually trees or shrubs, with simple or compound exstipulate leaves, dotted with aromatic glands; flowers regular; stamens as many, or twice as many, as the petals; fruit dry, frequently bursting when ripe. Example: *Ruta angustifolia*.

Order VII, Aurantiaceæ.—Trees or shrubs, with smooth, translucently glandular, alternate, exstipulate leaves, with the blade mostly jointed to the petiole; stamens with flattened filaments; petals imbricated, deciduous; fruit succulent; seeds without endosperm. Example: Orange, Lemon.

Order VIII, Meliaceæ.—Trees or shrubs, with alternate pinnate exstipulate leaves; flowers in panicles; stamens definite, monadelphous, or rarely free; anthers sessile in the orifice of the tube; ovary free; style 1. (The *Cedreleæ* are distinguished from other *Meliaceæ*, chiefly by the free stamens and the numerous winged seeds.) Example: *Azadirachta indica* (Ním).

Order IX, Simarubaceæ.—Trees or shrubs, with a bitter bark; alternate, exstipulate, usually compound leaves destitute of glands; flowers unisexual; stamens generally with a scale at the back of the filaments; fruit of 4 to 5 drupes round a common torus. Example: *Quassia amara*.

Order X, Burseraceæ.—Trees or shrubs, with resinous juice, and alternate compound leaves; ovules in pairs; fruit hard, dry, and indehiscent. Example: *Boswellia serrata* (Sálái, Labán).

Cohort II—*Celastrales*.

Trees or shrubs, rarely herbs, usually with undivided leaves; flowers regular, hermaphrodite; stamens generally as many as the petals, perigynous, or inserted on the disk, at the bottom of the calyx; ovary usually entire, with one or two seeds in each cell; radicle inferior.

Order I, Celastraceæ.—Trees or shrubs, with mostly simple alternate leaves; calyx and corolla imbricated; stamens as many as the petals, and alternate with them. Example: *Celastrus paniculata*.

Order II, Rhamnaceæ.—Trees or shrubs, with alternate

simple leaves and small regular flowers ; stamens perigynous, as many as the petals, and superposed to them. Example : *Zizyphus jujuba* (Byar, Kúl).

Order III, Ampelideæ.—Shrubs with watery juice and jointed stems, usually climbing by tendrils ; petals 4 to 5, valvate, caducous ; stamens as many as the petals, and superposed to them, springing from a disk, surrounding the ovary. Example : Vine (Angúr).

Cohort III—*Sapindales*.

Trees or shrubs, mostly with compound leaves ; flowers often irregular and unisexual ; calyx often adnate to the disk ; stamens usually definite, perigynous, or adnate to the disk ; ovary usually 3-celled, with one or two ovules in each cell ; seeds usually without endosperm ; embryo often curved, or convoluted, with inferior radicle.

Order I, Sapindaceæ.—Trees or shrubs, rarely herbs, with alternate pinnate leaves and small flowers, often arranged in panicles ; stamens commonly 8, often anisomerous ; ovary 2 to 3-celled, and lobed with generally two ovules in each cell ; seeds without endosperm ; embryo frequently curved, or convoluted. Example : *Litchi*.

Order II, Anacardiaceæ.—Trees or shrubs with resinous juice ; flowers small ; stamens alternate with the petals ; ovary usually 1-celled ; ovules solitary and pendulous ; fruit commonly drupaceous ; seeds without endosperm. Example : *Semecarpus anacardium* (Bhelá).

Series III—CALYCIFLORÆ.

Flowers usually with a calyx and corolla ; sepals usually cohering, often adnate to the ovary ; petals distinct, perigynous or epigynous ; disk adnate to the base of the calyx ; the stamens perigynous or epigynous ; ovary frequently inferior.

Cohort I—*Rosales*.

Trees, shrubs, or herbs, with usually hermaphrodite regular or irregular flowers ; carpels one or more, generally free ; styles one, or, if more, distinct.

Order I, Leguminosæ.—Herbs, shrubs, or trees, usually with alternate compound leaves, and irregular, often papi-

lionaceous, or regular flowers; stamens 10, sometimes indefinite, diadelphous, monadelphous or distinct; carpel solitary; seeds almost always without endosperm. Example: *Crotalaria juncea* (San).

Order II, Rosaceae.—Herbs, shrubs, or trees, with usually alternate stipulate leaves and regular flowers; stamens numerous, springing from the calyx; ovary of one or more free, or afterwards uniting, carpels; seeds one or few in each ovary, without endosperm. Example: Rose.

Order III, Connaraceae.—Trees or shrubs, with alternate compound leaves and regular flowers; stamens definite; ovaries 1 to 5, usually 5; 2-ovulate fruit mostly reduced to 1; 1-seeded follicle. Example: *Rourea* (Sukarthuntí).

Order IV, Crassulaceae.—Succulent herbs, with perfectly regular flowers; carpels opposite the petals, often with a glandular scale, at the base outside, distinct or more or less coherent; seeds very small, with fleshy endosperm. Example: *Bryophyllum calycinum*.

Order V, Droseraceae.—Mostly glandular hairy herbs, with regular hermaphrodite flowers; flower stalks circinate; ovary free with parietal placentas; seeds endospermic. Example: *Aldrovanda vesiculosa* (Máláká-jhánji).

Order VI, Saxifragaceae.—Herbs, shrubs, or trees, with alternate or opposite simple leaves; stamens 4 to 10, springing from the calyx; ovary more or less inferior; carpels of the ovary united, usually 2; seeds numerous containing endosperm. Example: *Saxifraga ligulata*.

Cohort II—*Myrtales*.

Trees, shrubs, rarely herbs, with simple, generally entire, leaves; regular, usually hermaphrodite flowers; and a syncarpous, generally inferior, ovary; styles united; placentation usually axile.

Order I, Myrtaceae.—Trees or shrubs, with usually opposite entire glandular leaves; calyx and corolla imbricated; stamens generally numerous; ovary inferior, with axile placentation; seeds usually indefinite, without endosperm. Example: *Psidium pomiferum* (Peyara).

Order II, Melastomaceae.—Herbs or shrubs, with opposite entire, usually 3-nerved, leaves; corolla twisted; stamens definite, with remarkable appendaged anthers bursting by

pores at the apex. Example: *Melastoma malabathricum* (Baraphutika).

Order III, Lythraceae.—Herbs, shrubs, or trees, with mostly opposite entire leaves, and no stipules; calyx valvate; petals corrugated; stamens definite; ovary free; seeds numerous, without endosperm. Example: *Lawsonia inermis* (Mendi).

Order IV, Onagraceae.—Herbs or shrubs, with usually 4-merous flowers; calyx valvate; corolla convolute; stamens definite; ovary 2 to 4-celled, inferior; seeds numerous. (*Trapa* is exceptional in having a 1-seeded ovary.) Example: *Trapa bispinosa* (Pani-phul).

Order V, Rhizophoraceae.—Trees or shrubs, with opposite stipulate leaves; calyx valvate; petals often fringed; stamens definite; ovary more or less adherent; seeds aperiispermic, germinating, and forming a long root before the fruit falls from the tree. Example: *Rhizophora mucronata* (has not fringed petals).

Order VI, Combretaceae.—Trees or shrubs, with opposite or alternate simple leaves; stamens mostly 10; ovary inferior, 1-celled, with pendulous ovules; seeds without endosperm. Example: *Quisqualis Indica* (Rangoon creeper).

Cohort III—*Passiflorales*.

Mostly twining or climbing herbs, with regular unisexual or hermaphrodite flowers; and a syncarpous unilocular ovary, with parietal placentation; sometimes 3-celled by the inflexion of the placenta.

Order I, Passifloraceae.—Herbaceous plants, climbing by tendrils; flowers hermaphrodite, numerous; filamentous processes springing from the tube of the corolla; stamens 5, monadelphous; ovary 1-celled, superior. Example: Passion-flower.

Order II, Cucurbitaceae.—Succulent herbaceous plants, prostrate or climbing by tendrils; flowers monœcious or dicecious; stamens from 3 to 5, often united by their sinuous anthers; ovary inferior, 3-celled; seeds without endosperm. Example: Melon (Khurbuj).

Order III, Begoniaceae.—Succulent herbs with alternate

leaves, often oblique at the base; flowers monœcious; perianth of two to many segments, not differentiated into calyx and corolla; stamens indefinite; ovary inferior, 3-celled. Example: *Begonia*.

Order IV, Papayaceæ.—Are trees or shrubs, sometimes with an acrid milky juice; alternate, palmatifid, long-stalked leaves, and unisexual flowers; ovary free, 1-celled; seeds endospermic. Example: *Carica Papaya* (*Pepiya*).

Cohort IV—*Ficoïdales*.

Succulent herbs, with regular flowers, bearing numerous imbricated petals, and unilocular syncarpous ovaries, with usually parietal placentas.

Order I, Cactaceæ.—Mostly prickly leafless plants, with fleshy and thickened stems, of peculiar aspect; flowers conspicuous, solitary sessile; the members of the calyx and corolla generally alike, and imbricated in numerous rows, adherent to the 1-celled ovary, with parietal placentas; stamens indefinite. Example: *Opuntia Dillenii* (*Nágh-phena*).

Order II, Ficoideæ.—Herbs or shrubs, often succulent, with inconspicuous flowers; calyx-lobes usually 4—5, distinct from the petals. Example: *Mollugo*.

Cohort V—*Umbellales*.

Plants with usually hermaphrodite flowers, arranged in umbels; stamens generally definite; ovary inferior; ovules solitary, pendulous; seeds endospermic.

Order I, Umbellifercæ.—Herbs, usually with fistular stems, and alternate exstipulate leaves, sheathing at the base, generally deeply divided; flowers in umbels; stamens 5, epigynous; styles 2; carpels 2, separating when ripe, dry, indehiscant. Example: *Hydrocotyle Asiatica* (*Thal-kuri*).

Order II, Araliaceæ.—Trees, shrubs, or herbs, with alternate simple or compound leaves; petals and stamens epigynous; styles usually more than 2; fruit, three or several celled, usually succulent, with one endospermic seed in each cell. Example: *Panax fruticosum*.

Order III, Cornaceæ.—Are mostly shrubs or trees, with

opposite simple exstipulate leaves ; flowers 4 to 5-merous ; ovary 1 to 2-celled ; style 1 ; fruit drupaceous. Example : *Aucuba Japonica*.

DIVISION II—*Gamopetalæ*.

Plants having both calyx and corolla, the latter gamopetalous ; stamens mostly epipetalous, rarely free ; pistil, usually syncarpous.

Series I—Ovary usually inferior, stamens isomerous, with (rarely fewer than) the lobes of the corolla.

Cohort I—*Rubiales*.

Shrubs or trees, rarely herbs, with opposite or verticillate, often stipulate, leaves ; flowers regular or irregular ; stamens epipetalous, as many as the corolla lobes ; ovary 2, many celled.

Order I, Rubiaceæ.—Herbs, shrubs, or trees, with opposite entire leaves, and interpetiolar stipules, or with verticillate leaves ; calyx adherent to the 2 to 4-celled ovary ; stamens as many as the lobes of the regular corolla, epipetalous ; seeds endospermic. Example : *Ixora coccinea* (Rangan).

Order II, Caprifoliaceæ.—Are mostly shrubs, with opposite exstipulate leaves ; stamens as many as the lobes of the usually irregular corolla ; ovary 1 to 6-celled ; seeds pendulous ; endosperm fleshy. Example : Honeysuckle.

Cohort II—*Asterales*.

Mostly herbs, with exstipulate leaves and regular or irregular flowers, often unisexual, collected in capitula ; calyx limb usually reduced to a pappus ; stamens as many as corolla lobes, rarely fewer ; ovary unilocular ; ovule solitary.

Order I, Compositæ.—Herbs or shrubs, with alternate or opposite leaves, with the flowers in dense heads upon a common receptacle, surrounded by an involucre ; stamens usually 5 ; anthers syngenesious ; ovary inferior, 1-celled, with one erect ovule ; seeds without endosperm. Example : *Zinnia*.

Order II, Dipsaceæ.—Are herbs; the flowers in dense heads, surrounded by an involucre, as in *Compositæ*, each floret surrounded by an involucrel; stamens 4; anthers distinct; ovary 1-celled, with one pendulous ovule; seeds endospermic. Example: *Dipsacus sylvestris*.

Order III, Valerianaceæ.—Are herbs, with opposite simple or compound leaves, and no stipules; calyx limb obsolete, or forming a pappus; stamens 1 to 5, distinct; seeds pendulous, without endosperm. Example: *Nardostachys Jatamansi*.

Cohort III—*Campanulales*.

Mostly herbs, with exstipulate leaves, and often milky juice; flowers usually irregular; stamens usually free from corolla; ovary generally from 2 to 6-celled; ovules numerous, rarely solitary.

Order I, Campanulaceæ.—Herbs with milky juice, alternate leaves, and regular flowers; stamens 5, mostly distinct; ovary 2 to 5-celled; seeds with fleshy endosperm. Example: *Campanula capensis*.

Order II, Lobeliaceæ.—Are herbs or shrubs, with alternate leaves, milky juice, and irregular flowers; stamens 5, syngenesious; ovary inferior, 1 to 3-celled; seeds endospermic. Example: *Lobelia trianguata*.

Series II—Ovary usually superior.

Section I—Flowers generally regular.

Cohort IV—*Ericales*.

Herbs, shrubs, or trees, with simple alternate leaves; stamens as many, or twice as many, as the corolla lobes, hypogynous or epipetalous; anthers opening by terminal elinks or pores.

Order I, Ericaceæ.—Are mostly shrubs, with regular flowers; anthers appendaged, opening by pores; ovary superior. Example: *Rhododendron*.

Order II, Vacciniaceæ.—Differ from the *Ericaceæ* in having inferior ovaries.

Cohort V—*Primulales*.

Herbs or shrubs, with exstipulate, usually alternate,

leaves; stamens equal in number to the corolla lobes, and opposite to them; ovaries unilocular, with free central placentation.

Order I, Plumbaginaceae.—Herbs or shrubs with regular 5-merous flowers; the five stamens superposed to the petals or lobes of the corolla; ovary 1-celled with five styles; ovule solitary. Example: *Plumbago zeylanica* (Chita).

Order II, Myrsinaceae.—Trees or shrubs, with alternate simple leaves and regular flowers; stamens 4 to 5, opposite lobes of corolla; ovary 1-celled, with free central placentation. Example: *Ardisia humilis* (Banjám).

Cohort VI—*Ebenales*.

Trees or shrubs, with alternate exstipulate leaves; stamens more numerous than the corolla lobes; ovary bi- or multi-locular; ovules usually few.

Order I, Ebenaceae.—Trees or shrubs, with alternate entire leaves and regular dioecious flowers, with numerous stamens. Example: *Diospyros embryopteris* (Gáb).

Order II, Styraceae.—Trees or shrubs, with simple alternate leaves; and usually hermaphrodite flowers; stamens numerous, epipetalous; ovary 2-celled, 1-seeded. Example: *Symplocos racemosa* (Lodh).

Order III, Sapotaceae.—Trees or shrubs, with alternate entire leaves and milky juice; flowers regular, hermaphrodite; stamens superposed to the lobes of the corolla, alternate with scales or sterile stamens. Example: *Mimusops elengi* (Bakúl).

Cohort VII—*Gentianales*.

Herbs, shrubs, or trees, usually with opposite or verticillate exstipulate leaves; stamens generally equal in number to the corolla lobes; ovary mostly syncarpous and bilocular.

Order I, Oleaceae.—Trees or shrubs, often with twining stems; leaves mostly opposite; stamens 2; ovary 2-celled, with 1 to 4 ovules in each cell. Example: Jasmine.

Order II, Apocynaceae.—Trees or shrubs, often twining or climbing, with entire, mostly opposite, exstipulate leaves; flowers regular, 5-merous; corolla twisted in the bud; stamens 5, alternate with corolla lobes; pollen granular; ovary

usually 2-celled, composed of two carpels, coherent in the ovarian and styler region, and quite blended in the dumb-bell shaped stigma. Fruit syncarpous or apocarpous ; seeds often comose. Example : *Vinea rosea* (Galphiringi).

Order III, Asclepiadaceæ.—Shrubs or herbs, often twining, with milky juice and opposite entire exstipulate leaves ; flowers regular, 5-merous ; stamens 5 ; stigmas forming a 5-angled fleshy head, to which the anthers are adherent ; pollen coherent into wax-like or granular masses ; carpels 2, usually distinct in the ovary, united in the stigmas. Example : *Calotropis gigantea* (Akanda).

Order IV, Loganiaceæ.—Trees, shrubs, or herbs, with opposite entire leaves and interposed stipules ; flowers regular ; stamens as many as, and alternate with, the corolla lobes ; ovary superior, usually 2-celled. Example : *Strychnos nux vomica* (Kuchila).

Order V, Gentianaceæ.—Herbs with bitter juice and opposite entire exstipulate leaves, or aquatic plants with floating leaves ; flowers regular, with a persistent calyx ; stamens as many as, and alternate with, the lobes of the corolla ; ovary 1-celled, with two parietal placentas and indefinite ovules. Example : *Exacum tetragonum* (Kúchhari).

Cohort VIII—*Polemoniales*.

Herbs, or shrubs, rarely trees, with usually alternate exstipulate leaves ; stamens as many as the corolla lobes ; ovary syncarpous, 1 to 5-celled ; seeds mostly numerous.

Order I, Solanaceæ.—Herbs, shrubs, or sometimes trees, with alternate exstipulate leaves, and regular or slightly irregular 5-merous flowers, often extra axillary ; stamens 5, as many as, and alternate with, the corolla lobes ; corolla plaited in æstivation ; ovary 2-celled ; seeds numerous, endospermic ; embryo curved. Example : *Solanum tuberosum* (Potato).

Order II, Polemoniaceæ.—Herbs or shrubs with alternate or opposite leaves, and regular 5-merous and 5-androus flowers ; the lobes of the corolla usually contorted in æstivation ; ovary 3-celled, with three styles ; seeds endospermic ; embryo straight. Example : *Polemonium ceruleum*.

Order III, Convolvulaceæ.—Chiefly herbs, twining or trailing, with alternate leaves, and regular 5-androus flowers ; calyx imbricated ; the funnel-shaped corolla indu-

plicate or plaited in the bud; ovary 2 to 4-celled, with one or two ovules in each cell; embryo large, curved, (*Cuscuta* is a leafless parasite.) Example: *Ipomœa bona-nox* (Kalmí-latá).

Order IV, Boraginaceae.—Mostly herbs, with alternate rough leaves, a scorpioid inflorescence, and symmetrical flowers; stamens 5, epipetalous; ovary deeply 4-lobed, surrounding the gynobasic style. Example: *Heliotropium Indicum* (Hátsúra).

Order V, Hydrophyllaceae.—Herbs with alternate leaves and scorpioid inflorescence; ovary 1-celled, with parietal placentation.

Section II—Flowers very irregular.

Cohort IX—*Lamiales*.

Herbs, shrubs, or trees, with exstipulate leaves and bilabiate flowers; stamens usually fewer than the lobes of the corolla, generally didynamous, rarely 2; ovary 2 to 4-celled; style simple; ovules mostly solitary.

Order I, Labiatae.—Herbs, rarely shrubs, with square stems, opposite aromatic leaves, and irregular flowers; stamens didynamous or diandrous; ovary deeply 4-lobed, surrounding the gynobasic style. Example: *Ocimum basilicum* (Túlsi).

Order II, Verbenaceae.—Herbs, shrubs, or trees, with opposite or alternate leaves and irregular flowers; stamens didynamous; ovary entire, 2 or 4-celled; style terminal. Example: *Siphonanthus Indicus* (Bámunhátí).

Cohort X—*Personales*.

Herbs, rarely shrubs or trees, with exstipulate leaves and bilabiate flowers; stamens usually fewer than the corolla lobes, and didynamous, rarely only 2; ovary generally 1 to 2-celled; style simple; ovules mostly numerous; fruit a capsule.

Order I, Scrophulariaceae.—Chiefly herbs, with opposite or alternate leaves and irregular flowers; corolla imbricated; stamens didynamous or diandrous, springing from the tube of the corolla; ovary 2-celled; fruit a 2-celled, usually many-seeded capsule. Example: *Lindenbergia ruderalis* (Haldí basanta).

Order II, Utriculariaceae.—Herbs growing in water or wet places; flowers with a 2-lipped personate spurred

corolla; stamens 2, ovary 1-celled, with a free central placenta. Example: *Utricularia stellaris* (Bara jhánji).

Order III, Orobanchaceae.—Fleshy parasitical herbs, destitute of green foliage, with purplish flowers; stamens didynamous; ovary 1-celled, with 2 to 4-parietal placentas; embryo rudimentary. Example: *Orobanche Indica*.

Order IV, Gesneraceae.—Are herbs or shrubs, often epiphytic; corolla usually tubular; ovary inferior or superior, 1-celled, with 2-lobed parietal placentas. Example: *Gloxinia speciosa*.

Order V, Bignoniaceae.—Usually woody, rarely herbaceous plants, often twining or climbing, with exstipulate, usually compound, leaves; flowers irregular; corolla trumpet-shaped; stamens didynamous or diandrous; ovary 2-celled; seeds numerous, winged, without endosperm. Example: *Bignonia suaveolens* (Pátalí).

Order VI, Sesamaceae or Pedaliaceae.—Herbs with opposite leaves and irregular flowers; stamens fewer than corolla lobes; seeds generally wingless. Example: *Sesamum Indicum* (Til).

Order VII, Acanthaceae.—Herbs or shrubs with opposite simple exstipulate leaves; flowers irregular, bracteate; stamens didynamous or diandrous; ovary 2-celled; with two or more ovules in each cell; fruit a 2-celled capsule; seeds without endosperm, usually flat, supported by hooked or cup-shaped projections of the wood or hardened placentas. Example: *Ruellia longifolia* (Kántá kúlíká).

DIVISION V—*Apetalae*, or *Incompleteae*.

Perianth consisting of only a single whorl of leaves, or altogether absent, or of a double whorl of sepaloid leaves, rarely of distinct sepals and petals.

Subdivision I—Ovary inferior.

Cohort I—*Santalales*.

Shrubs, rarely trees or herbs, with hermaphrodite or diclinous flowers; ovules usually reduced to a naked nucleus.

Order I, Loranthaceae.—Parasitic shrubs, with opposite or alternate exstipulate leaves; flowers perfect or diclinous; stamens 4 to 8, superposed to the segments of the coloured perianth; ovary inferior. Example: *Loranthus longiflorus* (Bara mandá).

Order II, Santalaceæ.—Herbs, shrubs, or trees, with entire leaves, stamens superposed to the lobes of the perianth; ovary 1-celled, with two to four ovules suspended from a free central placenta. Example: *Santalum album* (Chandan).

Cohort II—*Quernales*.

Trees with simple or compound leaves; flowers diclinous; the male flowers in catkins; the female solitary, or in spikes; perianth green; fruit 1-seeded; seeds without endosperm.

Order I, Cupuliferæ.—Trees or shrubs with alternate simple stipulate leaves and unisexual flowers; ovary usually a 2-3-celled; fruit a glans. Example: *Quercus* (Oak).

Order II, Juglandaceæ.—Trees with alternate pinnate exstipulate leaves; flowers unisexual; ovary 1-celled; fruit drupaceous. Example: *Juglans regia* (Akarot).

Cohort III—*Asarales*.

Herbs, or climbing shrubs, with hermaphrodite or diclinous flowers; perianth usually colored; fruit inferior, a capsule or berry; embryo minute.

Order I, Aristolochiaceæ.—Climbing shrubs or low herbs, with an irregular or regular perianth; valvate in the bud; stamens 6 to 12, more or less adherent to the style; ovary inferior; ovule 3 to 6-celled. Example: *Aristolochia Indica* (Ishwar mûl).

Subdivision II—Ovary superior.

Cohort IV—*Piperales*.

Plants with hermaphrodite or diclinous flowers, generally in spikes or catkins; perianth rudimentary; ovary usually unilocular, with a single ovule.

Order I, Piperaceæ.—Herbs or shrubs with jointed stems, and alternate or opposite simple leaves; flowers achlamydeous, diœcious, or hermaphrodite, in spikes or racemes; ovary 1-celled, with a single erect ovule. Example: *Piper betle* (Pán).

Cohort V—*Euphorbiales*.

Plants with hermaphrodite or diclinous flowers; perianth green or colored; ovary usually 3-celled; ovules one or two in each cell, pendulous, anatropous; fruit one, usually 3-celled.

Order I, Euphorbiaceæ.—Herbs, shrubs, or trees, mostly with milky juice and usually alternate stipulate leaves, and monœcious or diœcious flowers; ovary free, usually 3-celled, separating when ripe into cocci, with one or two pendulous ovules in each cell. Example: *Tragia involucrata* (Bichatí).

Cohort VI—*Amentales*.

Trees or shrubs with alternate, usually stipulate, leaves; flowers diclinous, in catkins, cones or heads; perianth absent or sepaloid; ovary 1 to 2-celled; seeds without endosperm.

Order I, Salicaceæ.—Trees or shrubs with diœcious flowers arranged in catkins; perianth rudimentary or none; ovary free, 1-celled; ovules indefinite; fruit capsular. Example: *Salix tetrasperma* (Páni Jamá).

Order II, Casuarinaceæ.—Pseudo leafless trees, with pendulous pointed striated branches; male flowers in spikes; female flowers in strobiles; stamen 1; ovary 1-celled, with one to two ascending ovules. Example: *Casuarina equisetifolia* (Jhau).

Cohort VII—*Urticales*.

Plants with usually diclinous flowers; perianth usually regular, green; stamens superposed to the perianth lobes; ovary generally 1-celled; ovule solitary; fruit simple or multiple, an achene or samara.

Order I, Urticaceæ.—Herbs, shrubs, or trees, with opposite or alternate stipulate leaves and small unisexual flowers; perianth green, free from the 1-celled ovary; stamens equal in number and opposite to the perianth lobes, uncoiling elastically; fruit simple—an achene; embryo straight. Example: *Urtica interrupta* (Lalbichatí).

Order II, Artocarpaceæ.—Trees or shrubs, rarely herbs, with milky juice and alternate stipulate leaves and diclinous flowers; female flowers in heads, or on flat receptacles; stamens non-elastic; ovary 1-celled; embryo straight or curved; fruit multiple. Example: *Artocarpus integrifolius* (Jack).

Order III, Cannabinaceæ.—This order is closely allied

to Urticaceæ, but differs in the non-elastic stamens and the curved embryo. Example: *Cannabis sativa* (Gunjá).

Order IV, Ulmaceæ.—Trees with watery juice and alternate stipulate leaves; flowers polygamous; fruit dry and winged or drupaceous. Example: *Celtis orientalis* (Jiban).

Cohort VIII—*Daphnales*.

Trees or shrubs with generally hermaphrodite flowers; perianth mostly tubular, green or coloured; ovary usually 1-celled; ovule generally solitary.

Order I, Elæagnaceæ.—Small trees or shrubs, with scaly leaves and dicecious or polygamous flowers; perianth tubular, contracted beyond the ovary; stamens as many as the lobes of the perianth, and alternating with them; ovary 1-celled; seed ascending. Example: *Elæagnus conferta*.

Order II, Proteaceæ.—Trees or shrubs with hard, dry exstipulate leaves, and usually hermaphrodite flowers; perianth 4-cleft, valvate; stamens 4, superposed to the segments; ovary single, free, with one or two, rarely more, ovules. Example: *Grevillea robusta*.

Cohort IX—*Laurales*.

Aromatic trees or shrubs with diclinous or hermaphrodite flowers; having a regular green or coloured perianth; ovary 1-celled; ovule solitary; embryo straight.

Order I, Lauraceæ.—Aromatic trees or shrubs, with alternate simple exstipulate leaves, and usually hermaphrodite flowers; perianth imbricated; stamens definite; anthers opening by valves; seeds solitary, pendulous, aperispermic. Example: *Camphora officinarum*.

Order II, Myristicaceæ.—Aromatic trees, with alternate, entire, leathery, exstipulate, dotted leaves; flowers diclinous; fruit succulent, 1-celled, 1-seeded, surrounded by an arillus; endosperm ruminated. Example: *Myristica moschata* (Jáyphal).

Cohort X—*Chenopodiales*.

Herbs or shrubs with unisexual or hermaphrodite flowers, and a generally regular green or coloured perianth; ovary

1-celled; ovule solitary; seeds endospermic; embryo usually curved.

Order I, Polygonaceæ.—Herbs or shrubs with alternate simple leaves, and usually ochraceous stipules above the swollen joints of the stem; flowers very small; ovary 1-celled, with three or two stigmas; ovule erect, orthotropous; fruit a triangular nut. Example: *Polygonum orientale* (Páimarieh).

Order II, Amarantaceæ.—Herbs or shrubs with opposite or alternate exstipulate leaves, and a bracteated inflorescence; perianth scarious or coloured; ovary 1-celled, 1-seeded, with a curved embryo. Example: *Amarantus gangeticus* (Lál-shák).

Order III, Chenopodiaceæ.—Chiefly herbs, more or less succulent, with usually alternate exstipulate leaves, and minute flowers, with a herbaceous perianth; ovary 1-celled, 1-seeded, with a coiled embryo. Example: *Chenopodium album* (Chandan betú).

Order IV, Nyctaginaceæ.—Herbs, shrubs, or trees, with mostly opposite entire leaves; stem tumid at the joints; perianth petaloid; long lower part persistent, enclosing, and often adhering to the fruit; ovary superior, 1-celled, 1-seeded; stamens one or several, hypogynous; radicle inferior. Example: *Mirabilis jalapa* (Kishnokeli).

DETAILS OF DICOTYLEDONOUS ORDERS.

Ranunculaceæ

Are herbs with alternate or climbing shrubs, with opposite exstipulate leaves and acrid juice; calyx and corolla usually deciduous; stamens indefinite; ovules anatropous; fruit a collection of achenes, a circle of follicles, or a one or more seeded berry; embryo very small; seeds endospermic.

The sepals and petals inserted on the thalamus, the indefinite stamens, the inverted ovules, the apocarpous fruit, and the presence of endosperm distinguish this order from its nearest allies.

The plants of this order are most abundant in damp, cool climates.

Clematis Gauriana flowers at the close of the wet season in the environs of the ancient city of Gaur, and along the

foot of the Himalayas: the flowers are small, white. *Naravelia zeylanica* (Chágalbátí) flowers during the rains, and is common in hedges in most parts of India: the flowers are of a yellowish colour. *Ranunculus Indicus* is the only species of crow's-foot found in the plains; it appears in marshy places and on the banks of rivers, during the cold season. A degenerate variety of *Delphinium consolida* (Larkspur) is generally met with in Indian gardens. *Nigella sativa* (Káljirá) flowers in the cold season: the seeds are procurable in most parts of India, and are sometimes used as a substitute for pepper. The dried root of *Coptisteeta* is imported from Assam; it is sometimes used as a tonic. *Aconitum napellus* is a native of the mountainous parts of Central Asia, extending to Northern India: the dried roots and leaves are used in medicine as a sedative. *Thalictrum foliolosum* is common throughout the temperate Himalayas; it is used as a tonic.

Fig. 93.

Achene as in *Naravelia zeylanica*, enlarged.

Other genera are: *Anemone*, L.; *Callianthemum*, C. A. Mey.; *Oxygraphis*, Bunge.; *Caltha*, L.; *Calathodes*, Hf. and Th.; *Trollius*, Don.; *Isopyrum*, L.; *Aquilegia*, L.; *Actæa*, L.; *Cimicifuga*, L.

Sir J. Hooker, in his *Flora of British India*, divides the Order *Ranunculaceæ* into five tribes:—Tribe 1, *Clematideæ* (*Naravelia*). Tribe 2, *Anemoneæ* (*Thalictrum*). Tribe 3, *Ranunculaceæ* (*Ranunculus*). Tribe 4, *Helleboraceæ* (*Coptis*). Tribe 5, *Pæoniææ* (*Pæonia*).

Dilleniaceæ

Are trees or shrubs generally with alternate leathery leaves furnished with conspicuous primary veins from the midrib to the margin; calyx persistent; stamens indefinite; seeds arillate, with fleshy endosperm.

The commonest tree of this order is *Dillenia Indica* (Chalita), which has alternate simple serrate leaves; it flowers during the hot season and at the beginning of the rains; the flowers are handsome, white, and fragrant. The fleshy

persistent calyx is eaten, it has an agreeable acid taste. The wood of the tree is hard and tough. Most of the species of *Dillenia* are very handsome, both as to foliage and flowers, and some of the larger kinds yield hard durable timber.

Climbing genera, *Delima*, L., *Tetracera*, L., and *Schumacheria*; non-climbing, *Wormia*, Rottb.

Magnoliaceæ

Are aromatic trees or shrubs with fragrant imbricated flowers; the sepals and petals are arranged in a ternary order; the leaf-buds mostly sheathed with membranous stipules; stamens indefinite; seeds often suspended by a long funiculus; endosperm fleshy, homogeneous.

Fig. 94.



Michelia champaca, L.

This order is easily distinguished from *Dilleniaceæ* by its stipules and *trimerous* flowers; and from *Anonaceæ*, by its imbricated corolla, and homogeneous fleshy endosperm. The best known tree of this order is *Michelia champaca*, L. (Chám-pá), the

flowers of which are excessively fragrant, sometimes being so oppressive as to induce headache: the bark is sometimes used as a tonic. The fruit of *Illicium anisatum*, a native of China, is used in this country in medicine; the seeds are aromatic. *Magnolia Campbellii* of Darjiling has extremely handsome flowers, which appear before the leaves.

Other genera are: *Talauma*, Juss.; *Liriodendron*, L.; *Euptelea*, Sieb. and Zucc.; *Manglietia*, Bl.; *Schizandra*, Mich.; *Kadsura*, Kæmp.

In Hooker's *Flora of British India*, this Order is divided into four tribes. Tribe 1, *Troehodendreae* (*Euptelea*). Tribe 2, *Winterea* (*Illicium*). Tribe 3, *Magnolieae* (*Michelia*). Tribe 4, *Schizandreae* (*Kadsura*).

Anonaceae

Are trees or shrubs with alternate entire exstipulate leaves; the sepals and petals are in a ternary order; corolla usually valvate in the bud; stamens indefinite, with enlarged connective; endosperm ruminated.

The plants of this order are at once distinguished from those of *Magnoliaceae* by the absence of stipules, the valvate aestivation of the corolla, and the ruminated endosperm. They are allied to the *Magnoliaceae* by their general aromatic and fragrant properties. The dry fruits are mostly aromatic and pungent, and the succulent kinds are sweet and agreeable to the palate.

Anona squamosa, L. (Ata), the custard apple, is the best known plant of this order; it flowers in the hot season, the fruit ripening about July and August. *Anona reticulata* (Noná) is also frequently met with; the fruits are hard and unpalatable. *Anona muricata* (Fig. 95 see next page), sour sop of the West Indies, grows readily in Lower Bengal; the flowers are large yellowish green, and are strongly scented. *Artabotrys odoratissimus*, R. Br., is a scandent shrub, climbing by means of hooked peduncles; the flowers are large, of a greenish yellow colour, and fragrant. *Guatteria longifolia* (Debdáí) is a large handsome tree of somewhat slow growth; the wood is soft and white; it flowers about February, and the fruit ripens during the rains.

Other genera are: *Uvaria*, L.; *Polyalthia*, Bl.; *Oxymitra*, Bl.; *Goniothalamus*, Bl.; *Mitrephora*, Bl.; *Melodorum*, Dun.;

Fig. 95.



Anona muricata, L.

Miliusa, Leschen.; Saccopetalum, Benn. Alphonsea, Hf. and Th.

Sir J. Hooker divides the Order into five tribes: Uvarieæ, Unonæ, Mitrephoreæ, Xylopieæ (*Anona*), Miliuseæ.

Menispermaceæ

Are climbing or twining shrubs, with alternate exstipulate leaves and usually diœcious 3-merous flowers; stamens

definite, superposed to the petals ; fruit of several 1-seeded drupelets ; embryo large, in scanty endosperm.

This order is readily distinguished from its nearest allies Magnoliaceæ and Anonaceæ, by its unisexual flowers, curved carpels, the absence of stipules, and its climbing habit.

Tinospora cordifolia (Gulancha) is one of the commonest wild plants in India, every hedge producing it in abundance ; it flowers during the greater part of the year ; the male flowers are arranged in axillary racemes, females solitary, very small, and of a yellowish colour ; the filiform adventitious roots, which sometimes attain to the length of 30 feet, are peculiar ; preparations of the root and stem are used as a tonic and diuretic, &c. The roots of *Jateorhiza calumba*, a native of eastern tropical Africa, and *Cissampelos Pareira*, a cosmopolitan tropical plant, are used extensively in India as tonics, &c. *Anamirta cocculus*, the seeds of which are employed for killing fish, also belongs to this order. The structure of the wood is peculiar, the fibro-vascular bundles being arranged in successive concentric rings.

An exception to the climbing habit occurs in *Cocculus laurifolius* of the Himalayas, which is a small erect tree.

The root of *Coscinium fenestratum*, a native of the forests of Ceylon and Malabar, is sometimes used as a substitute for Calumba root as a tonic.

Other genera are : *Aspidocarya*, Hf. and Th. ; *Parabæna*, Miers ; *Tiliacora*, Coleb. ; *Limacia*, Lour. ; *Cocculus*, DC. ; *Pericampylus*, Miers ; *Stephania*, Lour. ; *Cyclea*, Arn. ; *Lophophyllum*, Griff. ; *Pycnarrhena*, Miers ; *Hæmatocarpus*, Miers.

Hooker divides the Order into four tribes : *Tinosporeæ*, *Coeculeæ*, *Cissampelideæ*, *Pachygoneæ*.

Berberidaceæ

Are shrubs or herbs with regular hermaphrodite flowers, with the very caducous sepals and petals imbricated in the bud ; stamens hypogynous, as many as the petals, and superposed to them ; anthers opening by two recurved valves. The plants of this order are chiefly natives of temperate and mountainous regions.

Hooker divides the Order into two tribes : *Lardiza-*

baleæ, including the genera *Deeaisnea*, Hf. and T. ; *Parvatia*, Dene. ; *Holbœllia*, Wall ; and *Berberæ*, including the genera *Berberis*, Linn. ; *Epimedium*, Linn. ; *Podophyllum*, Linn.

Nymphæaceæ

Are aquatic plants with eordate or peltate floating leaves, and large conspicuous flowers. The partially petaloid sepals and numerous petals and stamens are imbricated in several rows. Pistil syncarpous. There is a small endosperm in the ripe seed, lying in the much larger perisperm.

This order is so anomalous in many respects, that it is difficult to decide as to its closest relationships. The structure of the rhizomes is that of monocotyledonous stems ; the habit relates them to *Hydrocharidaceæ* ; and the structure of the ovary has some affinity with *Alismaceæ* ; the embryo, however, is dicotyledonous. The ovary approaches the character of the *Papaveraceæ*, and the leaves are netted veined.

These plants are some of the commonest over all parts of India. *Nymphæa lotus* being so well known as scarcely

Fig. 96.



Nymphaea lotus, L.

to need description ; it blossoms more or less the whole year, but chiefly during the rains. *Nymphaea rubra* differs from the white variety only in colour. *Euryale*

ferox has small bluish purple flowers, and is nearly allied to the *Victoria regia* of South America, which has leaves measuring twelve feet across, and flowers about one foot in diameter, when expanded.

The seeds and rhizomes contain a quantity of starch, and are frequently eaten. The embryo in these plants is very small, and is enclosed in a separate sac, at the end of the copious perisperm. In the stem the fibro-vaseular bundles, formed alone of vessels and parenchymatous cells without wood, are quite isolated, destitute of cambium, and form

a complicated interlacement, closely resembling that found in monocotyledons.

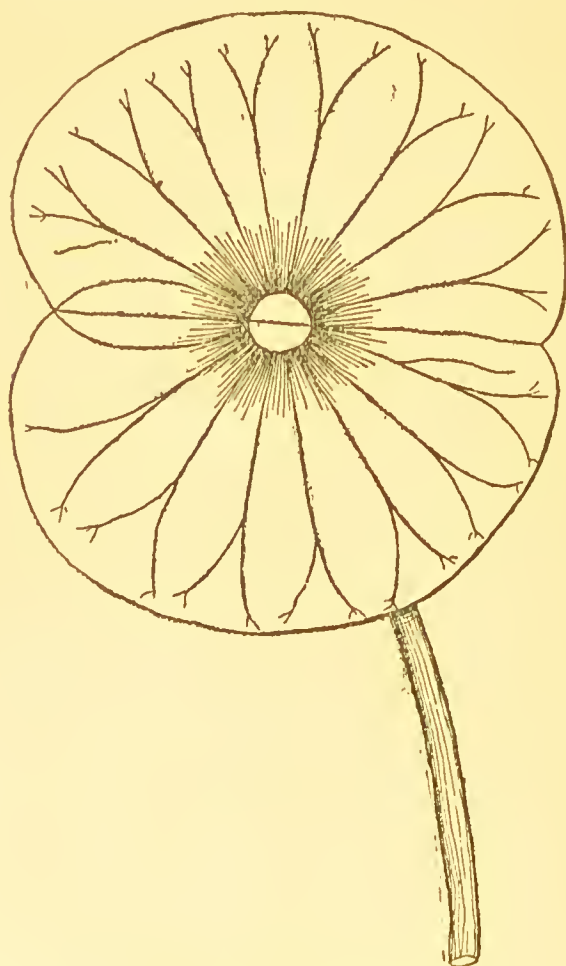
Other genera are: *Brasenia*, Schreber; *Nuphar*, L.

Nelumbiaceæ

Are large aquatic plants with peltate leaves raised above the water on long stalks; stamens indefinite; carpels distinct, imbedded in separate cavities of the enlarged thalamus; seeds solitary, without perisperm or endosperm.

These plants are nearly related to the *Nymphæacææ*. They have, however, distinct carpels and aperispermic seeds.

Fig. 97.



Peltate leaf of *Nelumbium speciosum*.

Nelumbium speciosum (Padma) (see Fig. 97) grows in large tanks, which do not dry up during the driest season ; it flowers about May, and the fruit ripens at the close of the rains ; the rhizomes, which contain a quantity of starch, are eaten either simply boiled, or in curries ; the seeds, which are also farinaceous, are eaten raw, roasted, or boiled ; and are supposed to be the sacred Egyptian bean, though no longer met with in Egypt ; they can, when kept dry, retain their power of germinating for a longer period than most other seeds. There is an authentic case of one of them, taken from an herbarium one hundred years old, germinating.

The leaves are sometimes used to eat off instead of plates. The petioles vary in length according to the depth of the water, being always sufficiently long to admit of the leaf being raised above the surface of the water.

Papaveraceæ

Fig. 98.



Papaver somniferum.

Are herbs with milky juice, alternate exstipulate leaves, and regular flowers ; sepals caducous ; stamens indefinite ; ovary syncarpous, 1-celled, with parietal placentas ; seeds with oily endosperm.

The nearest affinity to *Papaveraceæ* is *Fumariaceæ* ; the latter have, however, irregular flowers, diadelphous stamens, and watery juice.

Papaver somniferum, the opium poppy, is the most important plant of this order. Opium consists of the dried milky juice obtained from the unripe capsules ; it is largely cultivated in Behar ; the seeds afford a valuable oil. *Papaver rhæas*, the scarlet poppy, is found in gardens all over India. *Argemone Mexicana* (Bara-shelkántá) has become domesticated here,

the yellow flowers of which are conspicuous objects on every waste place; its capsules open by short valves or teeth; the seeds are narcotic acriid.

Other Indian genera are: *Meeonopsis*, Viguiér; *Cathcartia*, Hook. f.; *Stylophorum*, Nuttall.

Fumariaceæ

Are herbs with watery juice; flowers irregular; sepals 2, caducous, with six diadelphous, or four distinct, stamens; seeds endospermic. *Fumaria parviflora* (Banshulphá) is a common little annual, with very small rose-coloured dark purple-tipped flowers, found on cultivated land in the cold season. *Corydalis gowaniana* is a Himalayan plant, the roots of which are sometimes used as a tonic.

Other genera are: *Hypecoum*, Tournefort; *Dicentra*, Borkhaus.

Cruciferae

Are herbs with a pungent watery juice; the petals 4, arranged in a cruciform manner; sepals 4; stamens tetradynamous; fruit a silique or silicle; seeds without endosperm.

Fig 99.



Flower of *Cruciferae*, showing a cruciform corolla.

This order comes close to *Capparidaceæ* in the general character of the flower and in the seeds, but the tetradynamous stamens at once distinguish it.

The plan of the flower of this order is a subject of considerable controversy. The two lateral sepals are attached higher up than the other two; the four petals are in a single whorl. *De-Candolle* and others regarded the stamens as normally four, the pairs being formed by ehorisis. *Lindley* and others, on the other hand, regarded them as belonging to two circles of four, the outer of which has always two stamens abortive, while the inner pairs should normally stand singly before the four petals; in this case the glands in the receptacle are regarded as abortive stamens.

The most recent views as to the structure of the flower are those of Richler, who regarded them as consisting of two anteroposterior sepals, two lateral ones, four petals, two lateral short stamens, two anteroposterior long stamens, doubled by chlorisis, and two lateral carpels. The glands of the receptacle may sometimes be regarded as abortive stamens, or pistils, which would, if fully developed, render the flower symmetrical and isomerous.

The ovary is considered to be composed of two carpels, with a spurious dissepiment.

This order is very natural, and, as usually happens in such cases, the genera are very difficult to define. It has but few representatives in India, being most abundant in temperate and cold climates.

Sinapis dichotoma (Sarshá), *Sinapis glauca*, and *Sinapis ramosa* (Ráe) are largely cultivated in the cold season on account of the oil of their seeds. The fruit ripens about February. The oil of *glauca* and *ramosa* are largely used as an ingredient in food; the oil of *Sinapis dichotoma* is frequently used by the natives of this country to anoint their bodies with. *Raphanus sativus* (Múlá) is largely cultivated on account of the more or less fleshy eatable root. *Brassica oleracea* (Kopi), of which there are many varieties, is found only in a cultivated state. The fruit of all the above-named plants is siliquose. The commonest plant with a siliculose fruit is *Lepidium sativum*, cultivated during the cold season; it has a small white flower. *Iberis odorata* and *Iberis umbellata*, cultivated everywhere in gardens, have also got siliculose fruit. De-Candolle divided this large and very natural order into five sub-orders, founded on the mode of folding of the embryo: 1st, Pleurorhizæ; 2nd, Notorhizæ; 3rd, Orthoplocæ; 4th, Spirolobæ; and 5th, Diplocolobæ. Sir J. Hooker divides the order into ten tribes, established on the character of the fruit: Tribe 1, Arabideæ, including the genera Parrya, Nasturtium, Barbarea, Arabis, Cardamine, Loxostemon. Tribe 2, Alyssinæ, including the genera Draba, Cochlearia. Tribe 3, Sisymbrieæ, including the genera Lepidostemon, Sisymbrium, Eutrema, Erysimum, Christolea. Tribe 4, Camelinaæ, including the genus Braya. Tribe 5, Brassicæ, including the genus Brassica. Tribe 6, Lepidinea, including the

genera *Capsella*, *Lepidium*, *Dilophia*. Tribe 7, *Thlaspidæ*, including the genus *Thlaspi*. Tribe 8, *Isatidæ*. Tribe 9, *Cakilineæ*, including the genus *Crambe*. Tribe 10, *Raphanæ*. These tribes are all more or less artificial.

Capparidaceæ

Are herbs, shrubs, or trees, with alternate, usually compound leaves, and the sepals and petals 4-merous, stamens indefinite, or, if 6, not tetradynamous; ovary usually stalked; seeds reniform, without endosperm.

The plants of this order have a general resemblance to those of *Cruciferae*, but are distinguished by the stamens being often indefinite, or, if 6, not tetradynamous, by the gynophore, and by their reniform seeds. In their properties they somewhat resemble the *Cruciferae*. *Gynandropsis pentaphylla* (Kánálá) is an annual plant of from one to three feet high; the flowers are small, white; the stamens and ovary are supported on a long stalk (gynophore). *Polanisia viscosa* (Húrhúriyá) has small yellow flowers and indefinite stamens; the ovary is sessile; the young stems and the branches of old ones are hairy and glutinous; the seeds are pungent. The capers used as pickles are the flower-buds of various species of *Capparis*.

The order is divided into two tribes. Tribe 1, *Cleomeæ*, herbs. Tribe 2, *Cappareæ*, shrubs or trees.

Other genera are: *Cratæva*, L.; *Cadaba*, Forskah; *Roydsia*, Roxb.

Resedaceæ

Are herbaceous plants with alternate leaves, and unsymmetrical flowers, on a racemose or spiked inflorescence; stamens definite, inserted on a fleshy 1-sided disk; fruit usually 1-celled, opening at the top before the seeds—which have no endosperm—are ripe.

Reseda odorata (Mignonette) is cultivated in every garden in India; the ovary opening before the seeds are ripe, is an uncommon phenomena; the pollen grains are ellipsoid.

Other genera are: *Oligomeris*, Cambess, which is remarkable for the reduction of the parts of the flower, having but two petals and three stamens, and the disk is likewise absent. *Ochradenus*, Delile, are much branched shrubs.

Bixaceæ

Are trees or shrubs with alternate simple leaves, and hermaphrodite or unisexual flowers; stamens indefinite; ovary generally 1-celled; seeds numerous, with a usually straight embryo in the axis of the fleshy endosperm.

Bixa orellana (Latkan) is a small tree naturalized in India from South America, with entire leaves and terminal panicles of white flowers; the capsules contain a large number of red seeds, which yields a dye called *Arnatto*. *Gynocardia odorata*, a native of the forests of the Malayan Peninsula and Eastern India; the seeds yield a fixed oil (Chaulmúgra), used advantageously in cases of leprosy, &c. *Hydnocarpus inebrians* is a large tree with alternate leaves and dioecious axillary white flowers; the seeds resemble those of the chaulmúgra. *Flacourtia sepiaria* (Búinch), a small spinous shrub common on uncultivated land. *Cochlospermum gossypium* yields a gum, sometimes used as a substitute for tragacanth.

Other genus: *Xylosma*, Forster.

Violaceæ

Fig. 100.

*Viola odorata*.

Are herbs or shrubs with alternate, usually stipulate, leaves, and irregular hermaphrodite flowers, sepals, petals, and stamens 5, the connective of the anthers usually prolonged; ovary 1-celled, with three parietal placentas; stigma oblique, hooded; seeds endospermic.

Viola odorata, cultivated in gardens, is a low herb with alternate or radical, stipulate

simple leaves, and solitary irregular flowers; one of the petals and two of the filaments are spurred at the base. *Alsodeia Bengalensis* and *A. Roxburghii* are arborescent plants with small, nearly regular, flowers; they are common in the Khasia Hills, Ceylon, and the Malayau Peninsula.

Other genus: *Ionidium*, Vent.

Moringaceæ

Are trees with alternate, compound, stipulate leaves and irregular flowers; stamens arising from a perigynous disk; the 1-celled capsular fruit pod-like, with three parietal placentas; seeds without endosperm.

This order is sometimes placed near to Leguminosæ, but

Fig. 101.



Tri-pinnate leaf, as in *Moringa pterygosperma*.

differs widely from it on account of the parietal placentation. *Moringa pterygosperma* (Sujina) is one of the commonest cultivated trees in India, nearly all parts of it being used as food; it has winged seeds beautifully arranged in the fruit; the root has somewhat the taste of horseradish; a gum-like tragacanth exudes from the bark; in native medicine, the root, bark, leaves, flowers, and the gummy exudation from the stem are employed for various purposes.

Polygalaceæ

Are herbs, shrubs, or trees, with alternate, simple, exstipulate leaves, and irregular hermaphrodite flowers; stamens 4 to 8, diadelphous or monadelphous; anthers opening by pores; embryo straight, in abundant endosperm.

The somewhat papilionaceous corolla of this order has led to a comparison of it with Leguminosæ, from which, however, it differs widely; moreover, the position of the odd sepal will at once distinguish between them, being posterior in Polygalaceæ, anterior in Leguminosæ. From

Sapindaceæ they are readily distinguished by their straight embryo and endospermic seeds.

Polygala arvensis (Merádú) is a small, procumbent plant, a native of pasture lands; it has entire leaves, and racemose, irregular, inconspicuous flowers, produced during the rainy season. Senega, the root of *Polygala senega*, and Rhatany, the root of *Krameria triandra*, belong to this order; the former is used as an expectorant, the latter as a tonic and astringent. In *Salomonina*, a native of the Khasia Hills, the sepals are nearly equal. *Xanthophyllum*

is an arboreous genus, with five petals, four of which are nearly equal; the wood of these plants is hard, and is used for various purposes.

Other genus: *Securidaca*, Linn.

Fig. 102.



Dianthus, or Pink.

Caryophyllaceæ

Are herbs with opposite entire leaves; stems often swollen at the joints; flowers symmetrical, 4 to 5-merous; stamens definite; ovary 1-celled, with a free central placenta; embryo curved round the mealy endosperm.

Dianthus chinensis is a garden annual; easy of cultivation, with grass-like leaves, and terminal fascicled red flowers. The plants of this order are, for the most part, natives of temperate and cold climates, extending to the Arctic regions, and grow at great elevation in the Himalayas—one attaining

an altitude of 14,000 to 18,000 feet.

Sir J. Hooker divides the Order into three tribes: Tribe 1, Sileneæ, including the genera *Dianthus*, *Gypsophila*, *Silene*, *Cucubalus*, *Lychnis*. Tribe 2, Alsineæ, including the genera *Cerastium*, *Stellaria*, *Brachystemma*, *Arenaria*, *Sagina*, *Spergula*. Tribe 3, Polycarpeæ, including the genera *Drymaria*, *Polycarpon*, *Polycarpæa*.

Portulacaceæ

Fig. 103.



Portulaca.

Are succulent herbs; sepals 2; petals mostly 5; stamens generally indefinite; capsule 1-celled, with a free central placenta; embryo curved round the mealy endosperm.

Portulaca meridiana (Lúniyá) is a small creeping annual, hairy at the joints; it is common in gardens, growing as a weed; the flowers open at noon and close about 2 P. M.; the characters of the order are easier seen in the common garden species, *Portulaca thellusoni*. The motion of the stamens when touched is an interesting phenomena. The capsule opens by transverse dehiscence forming a pyxidium. Other genus: *Talinum*, Adans.

Tamaricaceæ

Are trees or shrubs with alternate, scale-like leaves, and flowers in close spikes or racemes; calyx 4 to 5, parted, persistent; stamens definite; capsule 3—5-valved, 1-celled,

with basilar placentation; seeds without endosperm.

The scale-like leaves of this order are very peculiar, and render it easily recognizable. *Tamarix Indica* (Jháu) is a small tree, generally found on sandy islands, in large rivers; it flowers during the latter part of the rains; the flowers are small, white, and very numerous. *Tamarix dioica* (Lál jháu) is also found on river islands; the flowers are very small and rose-coloured.

The galls of *Tamarix Indica* and *Tamarix dioica* are highly astringent, and are used both in medicine and dyeing.

Other genus: *Myricaria*, Desv.

Guttiferae

Are trees or shrubs with resinous juice and opposite leathery leaves; flowers unisexual or polygamous; sepals imbricated, in two or more decussating pairs; stamens often indefinite; ovary superior, one to many celled; stigmas sessile; seeds without endosperm.

This order is related to the *Hypericaceae*, but may be distinguished by the tree-like habit, the leathery leaves with articulated stalks, the binary arrangement of the flowers, the sessile radiating or peltate stigmas, and the seeds usually solitary in the cells of the ovary. *Calophyllum inophyllum* (Súltána-chámpa) is a handsome tree found cultivated over most parts of India; the flowers are white and fragrant. The mangosteen belongs to this order; it is the fruit of *Garcinia Mangostana*. *Garcinia Morella*, a native of Siam, yields a gum-resin, gamboge, which is used in medicine and also as a pigment. The seeds of *Garcinia purpurea*, of the Madras Peninsula, when bruised, give an oil, which is used for the preparation of ointments, &c.

The order generally is characterized by a coloured resinous juice with purgative properties.

Other genera are: *Mesua*, L.; and *Kayea*, Wall.

Hypericaceae

Are herbs or shrubs with opposite entire dotted leaves; flowers hermaphrodite; stamens polyadelphous; fruit usually tria or pentadelphous, or fleshy capsule with septicidal or loculicidal (eg., *Cratoxylon*) dehiscence; seeds numerous, without endosperm.

Hypericum Chinense is a small bushy shrub about two feet high, cultivated in gardens; the flowers are bright yellow. *Hypericum Japonicum* is a low procumbent herb, with small yellow terminal cymose flowers. *Hypericum Mysorensis* is common in Southern India.

Other genus: *Cratoxylon*, Blume.

Dipterocarpeæ

Are large trees abounding in resinous juice, with alternate pinnatifid stipulate leaves; calyx 5-lobed, imbricated, unequal, persistent; fruit, 1-celled, surrounded by the enlarged calyx, two or more lobes of which form winged appendages; seeds usually without endosperm.

The most characteristic feature of this order is the winged calyx forming a crown to the fruit; most of the plants also abound in resin. *Shorea robusta* (Sal), an immense timber tree; flowers during the hot season; it yields the dhoona, so much used as incense. Sumatra camphor is the resin of *Dryobalanops camphora*. Gurjun oil is the balsamic exudation of *Dipterocarpus trinervis*. Indian copal is the resin of *Vateria Indica*. *Hopea odorata* yields a fragrant resin, which, reduced to powder, forms a popular styptic amongst the Burmese. After flowering, two of the lobes of the calyx in *Dipterocarpus* and *Hopea* enlarge, giving rise to the name of the order, signifying a two-winged fruit.

Other genus: *Ansistrocladus* (endospermic), Wall.

Ternstroemiaceæ

Are trees or shrubs with watery juice and alternate, leathery, simple, exstipulate leaves; flowers hermaphrodite, rarely unisexual; stamens indefinite; ovary many-celled; styles distinct; seeds few, sometimes arillate; endosperm little or none.

This order is distinguished from Bixaceæ by the many-celled ovary and want of stipules; from Dipterocarpeæ, by the simple calyx and watery juice; from Tiliaceæ, by the imbricated calyx; and from Guttiferæ, by the alternate leaves, &c. *Thea Chinensis* is a low shrub, with alternate, shining, simple leaves, and axillary white flowers; there is a slight cohesion of the petals, which character is not infrequent in several normally polypetalous orders. The tea-shrub is found wild in the jungles of Assam. *Black* and *green* tea are produced by the same plant, the difference consisting in the time of picking and mode of preparation of the leaves. The young leaves, quickly dried and subjected to a particular kind of manipulation, supply the green tea; while the older leaves, dried more slowly and

after undergoing a process of fermentation, constitute the black tea. Tea contains oily matter, tannine, and the bitter principle called Theine, which is identical with Caffeine. *Saurauja Roxburghii* is a native of Sylhet; it has small rose-coloured flowers, which appear in July and August.

Other genera are: *Anneslea*, Wall.; *Eurya*, Thunb.; *Gordonia*, Ellis.; *Camellia*, Linn.; *Adinandra*, Jack.; *Cleyera*, D. C.; *Actinida*, Lindl.; *Stachyurus*, Sieb.; *Schima*, Reinw.; *Pyrenaria*, Blume.; and *Cochlospermum*, which last yields the gum called Kutiea, which, in the N. W. Provinces of India, is substituted for tragacanth.

Malvaceæ

Fig. 104.



Hibiscus rosa sinensis (reduced).

Are herbs or shrubs with alternate stipulate leaves and regular flowers; calyx valvate, and corolla contorted in æstivation; stamens numerous, monadelphous, with 1-celled anthers; seeds with little or no endosperm.

Malvaceæ is closely allied to *Sterculiaceæ* and *Tiliaceæ* by their ge-

neral structure and the æstivation of the calyx, but are distinguished by their 1-celled anthers. Many of the plants of this order are mucilaginous, and the liber affords a useful fibre. *Hibiscus rosa sinensis* (Jabá) (Fig. 104), cultivated all over India, is a shrub with alternate, simple, serrate leaves and large handsome flowers; it continues in flower the greater part of the year. *Gossypium herbaceum* (Kápás), the ordinary Indian cotton-plant, has large yellow flowers, with a dark-red centre. Cotton consists of the delicate, long, thin-walled hairs, which clothe the seeds: several varieties of this plant, as well as some other allied species, are now extensively cultivated in India. The commercial value of the cotton depends upon the length and tenacity of the hairy cells. *Hibiscus esculentus* (Dhenrú, okra), grows to about three feet high, and has large yellow flowers, with red centre; the ripe capsules are largely used as a vegetable. *Hibiscus cannabinus* (Mestápát) has large yellow flowers; the fibrous liber of the stem is used for cordage, &c. *Hibiscus vitifolius* (Ban-kapas) is a common plant. *Bombax Malabaricum* (Shimál) is a large tree found almost everywhere; flowering time the end of the cold season, when the tree is almost totally destitute of leaves; the great number of large red flowers, with which it is then covered, render it conspicuous at a great distance: the hairs of the seeds cannot be spun like cotton, but are used for stuffing cushions. The root of *Sida acuta* is used in Bengal as a bitter tonic. The root of *Sida retusa* is also held in some repute in the treatment of rheumatism. The viscid juice of the fruit of *Thespesia populnea* is used in Southern India as a local application in cutaneous diseases. *Adansonia digitata*, an African tree, now domesticated in many parts of India, deserves notice for the repute it has obtained as a remedy in dysentery. The Durian fruit is the product of a Malayan tree of this order, *Durio zibethinus*.

Other genera are: *Althæa*, Linn. (Golthyrá); *Urena*, Linn. (Ban-okra); *Abutilon*, Gærtn. (Petari); *Malvastrum*, A. Gray; *Pavonia*, Cav.; *Dicellostyles*, Benth.; *Kydea*, Roxb.; *Eriodendron*, D. C.

Sterculiaceæ

Are trees, shrubs, or herbs, with alternate simple or

compound leaves, and free deciduous stipules; calyx valvate; stamens monadelphous, with 2-celled anthers.

The 2-celled anthers separate the plants of this order from Malvaceæ, and the monadelphous stamens from Tiliaceæ. *Sterculia fatida* (Jangli-bádám), a large tree, with alternate digitate deciduous leaves, crowded about the ends of the branches; flowers large, of a dull crimson; the seeds are sometimes eaten roasted. *Helicteres isora* (Antamorá), a small, thinly branched tree, which flowers during the rains and cold weather. *Heritiera minor* (Súndrí), a native of the lower part of the delta of the Ganges; it is largely used as firewood. Cocoa is obtained from the seeds of *Theobroma cacao*. *Pentapetes phœnicea* (Dúpahariya) is common over the Peninsula of India, Java, Malaccas, &c.; the flowers are large, of a scarlet colour, and appear in the rainy season. *Pterospermum acerifolium* (Kanak-chámpá) has large white fragrant flowers, which appear during the hot season. *Abroma augusta* (Olat-kambal) has dark purplish brown flowers; the liber is used for cordage.

Sir J. Hooker divides the order into six tribes. Tribe 1, Sterculiæ, including the genera *Sterculia*, Linn., and *Heritiera*, Aiton. Tribe 2, Helicteræ, including the genera *Reevesia*, H.; *Helicteres*, L.; *Pterospermum*, Schreb. Tribe 3, Eriolænæ. Tribe 4, Dombeyæ, including the genera *Pentapetes*, L.; *Melhania*, Forsk. Tribe 5, Hermannieæ, including the genera *Melochia*, Linn.; *Waltheria*, Linn. Tribe 6, Buettneriæ, including the genera *Abroma*, Jacq.; *Guazuma*, Plum.; *Buettneria*, Linn.

Tiliaceæ

Are trees, shrubs, or herbs, with usually alternate simple stipulate leaves and regular flowers; calyx valvate; stamens indefinite, free, or united in bundles with 2-celled anthers.

The free or polyadelphous condition of the stamens and the 2-celled anthers separate this order from Sterculiaceæ and Malvaceæ, its nearest allies; the general properties are the same as in those orders—mucilaginous juices and fibrous bark.

Corchorus capsularis (Pát) is a smooth annual, cultivated during the rains; it has alternate simple leaves and

axillary fascicles of small yellow regular flowers; the tough fibrous liber of the bark affords "jute," which is extensively substituted for hemp; the fruit is an oblate capsule,

Fig. 105.



Grewia Asiatica.

in which the seeds are separated from each other by transverse partitions. *Corchorus Olitorius* is cultivated for the oil yielded by its seeds, also as a potherb; the fruit is a roundish capsule. The genus *Grewia* is numerous in species both in tropical Asia and tropical Africa. *Grewia Asiatica* (Phalsá) (Fig. 105) is a small tree, with round, cordate, serrate, downy leaves; the flowers are small, yellowish orange colour; the petals are glandular; the fruit ripens about April and May, and is palatable to some people. The genus *Elæcarpus*, including some large Indian trees, are marked by the anthers dehiscing at their tips; the petals also are usually fringed; the stones of its drupaceous fruits are strung together as beads.

Sir J. Hooker divides the order into two series: series 1, Holopetalæ, including the genera *Brownlowia*, Roxb.; *Grewia*, Linn.; *Triumfetta*, Linn.; and *Corchorus*, Linn. Series 2, Heteropetalæ, including the genera *Echinocarpus*, Blume.; *Elæocarpus*, Linn.

Geraniaceæ

Are herbs or shrubs with articulated swollen joints and membranous stipules; leaves aromatic; flowers 5-merous; stamens mostly 10; carpels 5, supported on a carpophore, from which they separate when ripe by the elastic segments of the style.

Fig. 106.



Fruit of *Geranium*.

The peculiar fruit, the stipules, and the swollen joints of the stem separate this order from its nearest allies. *Pelargonium zonale* is the common scarlet geranium cultivated in gardens. In India, geraniums have to be protected during the hot weather from the sun and wind, and in the rains from the drenching wet.

Other genera are: *Monsonia*, Linn.; *Geranium*, Linn.; and *Erodium*, L'Herit, which belong chiefly to the temperate parts of the northern hemisphere. *Pelargonium* (Fig. 107) abounds in species in South Africa. The *Balsaminaceæ* are

Fig. 107.

*Pelargonium.*

nearly related to this order, and is included in it by Benthams and Hooker, but may be distinguished by the want of the peculiar carpophore, and by the much greater irregularity of the flower. It includes the genera *Impatiens*, L. (Dopáté), and *Hydrocera*, Blume (Domúté). The name of the genus

Impatiens is derived from the elasticity with which the capsule bursts when ripe.

Linaceæ

Are herbs or shrubs with simple, alternate, undivided leaves, without stipules; flowers mostly 5-merous throughout; calyx imbricated; stamens coherent at the base; styles distinct; capsule many-celled, each cell divided by a false septum from the dorsal suture; seeds rarely without endosperm.

The simple entire leaves, and the peculiar structure of the fruit, are distinctive marks of this order.

Fig. 108.



Linum usitatissimum.

Linum trigynum (Gúlasraph) is a shrubby plant, with alternate oval leaves and bright yellow inodorous flowers; flowering time the cold season. *Linum usitatissimum* (Tisi), much cultivated over the northern parts of India for the seed, from which linseed oil is extracted, is a slender herb with fugacious blue flowers. Flowering time the cold season. The slight cohesion of the filaments and the minute teeth projecting in the intervals between the filaments, indicate a second series of undeveloped stamens. In *Erythroxylon*, an allied genus, there are ten perfect stamens, without any rudimentary ones.

Flax consists of long thick-walled liber cells, resembling jointed cylindrical rods. The microscopic appearance differs very considerably from that of cotton.

Dimorphism occurs in the genus *Linum*.

Other genera are: *Reinwardtea*, Dumort; *Anisadenia*, Wall; and *Ixonanthes*, Jack.

Oxalidaceæ

Are herbs, rarely shrubs, with alternate compound leaves and regular symmetrical 5-merous flowers; stamens 10, somewhat monadelphous; styles distinct; sepals imbricated, petals convolute in æstivation; capsule 5-celled; seeds endospermic.

This order can be easily distinguished from Linaceæ by its compound leaves and the absence of septa in its capsules; from Geraniaceæ, by the absence of the carpophore. The leaves of many of the plants of this order are sensitive, especially those of

Fig. 109.



Oxalis corniculata, showing the leaflets depressed.

the rains. *Oxalis corniculata* (Amrúl) is a small ereeping ramous herb, with ternate leaves and small yellow flowers, common everywhere, and is in flower and fruit most part of the year.

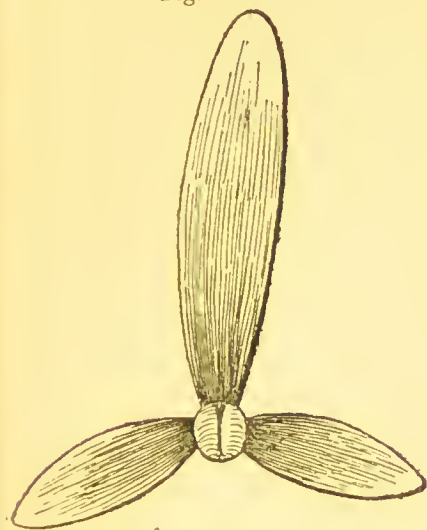
Malpighiaceæ

Are climbing shrubs with opposite entire stipulate or exstipulate leaves; calyx glandular; petals clawed; stamens mostly 10; carpels 3, often winged; ovules solitary, pendulous; seeds without endosperm.

The symmetrical flowers, the glands in the calyx, the long stalks in the petals, and the solitary ovules distinguish this order from its nearest allies. *Hiptage madagblota*, a climbing shrub, with opposite entire leaves and fragrant irregular yellow-white flowers; the young parts of the plant are covered with peltate hairs; the fruits are winged. *Malpighia coccifera* is a small shrub cultivated

in gardens, with small white flowers, having a slight tinge of rose colour.

Fig. 110.



Fruit of *Hiptage Madablota*.

The stems of some of the climbing species are peculiar in having part of the fibro-vascular bundles separate from the principal circle, and which lay the foundation of a number of secondary cylinders of wood, enclosed by a common bark.

The genus *Aspidopterys*, A. Juss., belongs to this order.

Zygophyllaceæ

Are herbs or shrubs with opposite, stipulate, compound leaves; flowers in axillary peduncles; stamens free, 8 to 10, often with a scale at the

base or middle of the filament; fruit various.

Tribulus terrestris (Gokhúr) is a prostrate herb, with opposite, stipulate, pinnate leaves, and bright yellow sweet scented flowers; it is common in pasture land in many parts of India, and flowers most part of the year.

T. lanuginosus, a variety of *T. terrestris*. All parts of this plant, but especially the fruit, are held in high repute in Southern India as a diuretic. *Guaiacum officinale* is a native of the West Indies; it has small blue flowers; the wood and resin are imported for medicinal purposes; the wood is very hard and heavy, and is known as "Lignum-vitæ." To this order belongs also *Fagonia*, with trifoliolate leaves; it is common in some of the dry parts of India.

Aurantiaceæ

Are trees or shrubs with smooth, glandular, alternate, exstipulate leaves, with the blade jointed to the petiole; stamens with flattened filaments; petals imbricated, deciduous; fruit succulent; seeds without endosperm.

These plants are generally distinguished by their dotted leaves, the blade of the leaf jointed to the petioles, the decidu-

ous imbricated petals, and the succulent fruit. *Citrus acida* (Nebú) is a shrub, with oval or oblong crenate leaves and winged petioles; there are many varieties; the commonest are: Pati-nebú, with a round fruit; Kágají-nebú, having a long small fruit; and Gorá-nebú, a thick-skinned small oval lime. *Citrus decumana* (Bátábi-nebú) is a small tree, of which there are two varieties,—one of which has the pulp of the fruit white, the other red: it is largely culti-

Fig. 111.

*Citrus aurantium.*

vated. *Citrus aurantium* (Nárangí) is the sweet orange. *Citrus medica*, the common citron; the flowers are white, tinged with red. *Feronia elephantum* (Kathbel), a large tree yielding very hard timber, found in most parts of India; the pulp of the fruit is sometimes used as a jelly. *Ægle marmelos* is a small tree largely cultivated for the sake of its

fruit, which is astringent, and is occasionally given in cases of dysentery: the bark of the tree is sometimes used in intermittent fevers.

Glycosmis pentaphylla (Ashshaurá) is a very common shrub with small white fragrant flowers; the small branches

are frequently used instead of a tooth-brush. *Murraya exotica* (Kámini) is much cultivated; the flowers are white, and strongly fragrant. The rind and leaves of these plants contain a large number of compound internal glands or reservoirs, surrounded by a special layer of cells lying just beneath, or sometimes rising in a dome shape a little above the surface of the epidermis.

Meliaceæ

Are trees or shrubs with alternate, pinnately compound, exstipulate leaves; flowers in panicles; stamens definite, monadelphous, or rarely free; anthers sessile or stipulate in the orifice of the staminal tube; ovary free; style one; fruit succulent or capsular; seeds perispermic.

The staminal tube and the leaves, which generally

Fig. 112.



Melia Azadirach (reduced).

are not dotted, distinguish this order from Auran-
tiaceæ, which is
its nearest ally.
Melia Azadirach
is a middle-sized
tree, with bipin-
nate or tripinnate
leaves and large
panicles of pur-
plish white sweet-
ly-scented flow-
ers, produced at
the end of the cold
season. *Azadi-
rachta Indica*
(Nim) is a com-
mon, very useful,
tree, with pinnate
leaves and small
white scented
flowers. The
bark is given in

cases of intermit-
tent fever; a poultice of the leaves is frequently used for

bruises and sores; from the fruit a bitter oil is expressed. *Swietenia mahoganii* and *Cedrela toona* also belong to this order; the latter is distinguished from the other Meliaceæ by its free stamens and numerous winged seeds. *Chloroxylon swietenia* is the Indian satinwood; the leaves are dotted.

The Order is divided into four tribes: Tribe 1, Meliæ, including the genera *Munronia*, Wight; *Melia*, Linn.; *Cipadessa*, Blume. Tribe 2, Triehiliæ, including the genera *Dysoxylum*, Blume; *Chisocheton*, Blume.; *Aglaia*, Lour.; *Amoora*, Roxb.; *Walsura*, Roxb.; *Heynea*, Roxb.; *Carapa*, Aubl. Tribe 3, Swieteniæ, including the genera *Swietenia*, L.; *Chiekrassia*, A. Juss. Tribe 4, Cedreleæ, including the genera *Cedrela*, L.; *Chloroxylon*, D. C.

Rhamnaceæ

Are trees or shrubs with alternate simple leaves and small regular flowers; stamens perigynous, as many as the petals, and superposed to them; berry or pod, with one seed in each cell, endospermic.

The perigynous stamens, superposed to the petals, distinguish this order from its nearest affinities. *Zizyphus jujuba* (Byar) is a thorny shrub, with alternate, 3-nerved, serrate leaves, and small green flowers in axillary umbellate fascicles; flowering time the rainy season; the fruit is eatable, about the size of a large cherry, yellow when ripe; it is a very common shrub, and is found growing wild everywhere. *Zizyphus Napeca* (Shyákál) is also very common; it is a climbing shrub with large straggling branches, which are too weak to support themselves; leaves alternate, short-petioled, obliquely ovate, serrate, 3-nerved; the drupe, the size of a pea, is smooth and black. *Zizyphus lotus* is supposed by some to be the lotus of the ancients.

Other Indian genera are: *Ventilago*, Gærtn. (*Rakta-pita*); *Hovenia*, Thunb.; *Colubrina*, Rich.; *Gouania*, Linn.; *Rhamnus*, Linn., &c.

Ampelideæ or *Vitaceæ*

Are shrubs with watery juice and jointed stems, climbing by tendrils; petals 4 to 5, valvate, caducous; stamens as many as the petals, and superposed to them, springing from a disk surrounding the ovary; fruit succulent; seeds perispermic.

The climbing habit and the hypogynous stamens superposed to the caducous petals serve to distinguish this order from its nearest allies. *Vitis vinifera* (Angúr), a shrub climbing by tendrils, with alternate lobed leaves and small green flowers, which appear about February; the fruit ripens during the hot season. This plant is cultivated in all the temperate regions of the globe. Tartaric acid is obtained from the acid-tartrate of potash deposited during fermentation from the juice of the grape. *Vitis Indica* (Amklouká) is a native of various parts of India, flowering in the month of April; leaves alternate, petioled, round, cordate, serrate; flowers small, greenish purple. *Vitis quadrangularis* (Harjora)—this is one of the most common plants in India, flowering during the rains; stems quadrangular, succulent, and smooth; the leaves alternate, serrate, reniform, cordate, and smooth; flowers 4-merous; berry, size of a small pea. *Leea macrophylla* (Tolsamúdhriyá) is very common in India; stem erect, annual, jointed; leaves simple, alternate, broad, cordate, serrate; flowers 5-merous, numerous, small, white; berry, size of a small cherry, black and succulent when ripe. *Leea crispa* (Ban-chálitá) is also very common; the flowers are small, white.

The tendrils by which the plants of this order climb are modified flower branches, often exhibiting a few nodules representing abortive flowers. The tendrils are given off opposite to the leaves, and not as axillary branches; each tendril and panicle is regarded as an axis, the lower portion of which forms the internode of the main stem; the succeeding internode of the stem is a new and distinct axis, originating in the axis of the leaf, opposite to which the tendril is given off. The Malayan genus, *Pterisanthes*, is peculiar in having the flowers arranged on a membranous expansion of the peduncle.

Sapindaceæ

Are trees or shrubs, rarely herbs, with alternate pinnate leaves and small flowers, often arranged in panicles; stamens 5 to 10, often anisomerous; ovary 2 to 3-celled, and lobed, with generally two ovules in each cell; seeds without endosperm; embryo mostly curved or convolute.

The peculiar convolution of the embryo is a marked

character in many of the Sapindaceæ, also the frequently unsymmetrical and irregular flowers.

Cardiospermum Halicacabum (Naphatkí) is a climbing

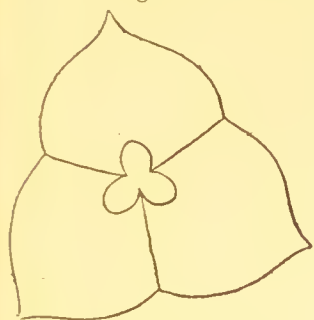
Fig. 113.



Cardiospermum Halicacabum.

herb, very common in India, in flower and fruit nearly all the year, with alternate leaves and small irregular flowers arranged in panicles; the capsules are inflated and membranous. *Nephelium litchi*, a tree largely cultivated for the sake of its delicious fruit; the apetalous flowers are small, greenish white; flowering time February and March; the fruit ripens in April and May.

Fig. 114.



Section of the fruit of *Cardiospermum Halicacabum*.

Nephelium longan (Ashphul), a tree having a short straight trunk with a large dense globular head; the fruit is sometimes eaten; the wood is hard, close-grained, and white as in the Litchi. *Dodonaea viscosa* is a shrub with narrow, entire, viscid leaves and small yellowish unisexual flowers. Various species of *Acer*, a genus having simple leaves, are common in the mountains of Northern India.

The order takes its name from the saponaceous principle contained in the fruits of species of *Sapindus*, which makes a lather with water; hence the fruits are used for washing, as in *S. detergens* (Rítá) and *S. emarginatus* (Bara-rítá).

The wood of the stems of some genera presents anomalous conditions, from the distribution of the fibro-vascular structures into several groups, so that the trunks have a number of woody axes besides that surrounding the pith, all enclosed within a common bark.

Other genera are: *Dodonaea*, L.; *Schleichera*, Willd.; *Harpullia*, Roxb.; *Cupania*, Plum.; and *Schmidelia*, Roxb.

Anacardiaceæ

Are trees or shrubs with resinous juice; flowers small; stamens alternate with the petals; ovary 1-celled in the tribe *Anacardiæ*, with a solitary ovule pendulous from a long basilar funicle; 2 to 5-celled in the *Spondiæ*, with ovules pendulous from the apex; fruit commonly drupaceous; seeds without endosperm.

The solitary ovule with ventral raphe, and inferior

micropyle or dorsal raphe if the micropyle be superior, are the prominent differential characters of this order. *Mangifera Indica* (Am), one of the best known trees in India, with numerous varieties, yields the well-known drupe called the mango; flowering time January, February, and March; the fruit ripens in May, June, or July; the flowers, which are arranged in panicles, are small yellowish green: many perfect male flowers are often found mixed with the hermaphrodite ones throughout the panicles; in these the stamens, except one, are usually abortive; the duramen of

Fig. 115.



Fruit of *Anacardium occidentale*.

the wood is durable; the other parts soon decay on exposure to the wet. *Anacardium occidentale* (Hijili báddám) is a tree with a very peculiar fruit; the kidney-shaped fruit springs from the fleshy receptacle; it flowers in March and April; the kernel of the seed is sometimes eaten. *Semecarpus anacardium* (Bhelá) is a tree, a native of the mountainous parts of India; the black acrid juice of the nuts is used in marking cloth, and the exudation from the stem furnishes a varnish. *Pistacia vera* produces pistachio nuts. *Spondias dulcis* (Biláti ámrá) is a large tree cultivated in gardens; the flowers are small, greenish yellow, and appear in March; the fruit ripens at the close of the rains. *Spondias mangifera* (Amrá) is also cultivated; flowering time the beginning of the hot season, when the leaves come out; the fruit ripens during the cold season, and then its leaves are deciduous. *Rhus succedanea* is a tree of the

sub-tropical and temperate Himalayas, known by the name of Kakra-singhi, from the horn-like excrescences borne on its branches, caused by insects.

Melanorrhœa usitata is a large tree, every part of which abounds with a thick, viscid, greyish, terebinthinate fluid, which soon assumes a black colour on exposure to the air; this is the black varnish of the Burmese, by whom it is extensively employed. *Odina Wodier* (Jiol) is a large tree, common throughout India; the bark is very astringent; the wood of old trees is close-grained, of a deep reddish mahogany colour towards the centre; large quantities of gum exude from fissures in the bark.

Other genus: *Buchanania*, &c.

Leguminosæ

Fig. 116.



Papilionaceous Flower, etc., of a Pea.

Are herbs, shrubs, or trees, usually with alternate compound leaves and irregular, often papilionaceous or regular, flowers; stamens 10; sometimes indefinite, diadelphous, monadelphous or distinct; carpel solitary; seeds usually aperi-spermic.

This large order presents very considerable varieties of structure, and but one character is absolutely constant, *viz.*,

the position of the sepals, the odd sepal being always anterior. The affinity with Rosaceæ is very close; but it may be noticed that, in Leguminosæ when the flower is regular, the fruit is leguminous. The irritability of the leaves of many leguminous plants is a striking characteristic; it is most remarkable in *Smithia*, *Desmodium*, and in *Mimoseæ*. This order may be divided into three sub-orders, which are distinguished by the following characters:—1st, *Papilionaceæ*: corolla papilionaceous, imbricated in the bud, the odd petal or vexillum exterior; 2nd, *Cæsalpineæ*: corolla imbricated in the bud, the odd petal interior; 3rd, *Mimoseæ*: corolla valvate in æstivation.

Papilionaceæ. The corolla in this sub-order is composed

Fig. 117.



Parts of a Papilionaceous Corolla.

of five petals, of which the posterior or the vexillum, or standard, is usually the largest and symmetrical in form; the two lateral, mostly oblique in form, are the alæ or wings; and the two anterior, also small and oblique, often coherent in front, form the carina or keel. Noteworthy plants of this sub-order are *Crotalaria juncea* (San), an annual plant, cultivated over India for its fibre; the

flowers are large, yellow, and appear during the rains and cold season. *Indigofera tinctoria* (Níl), largely cultivated over some parts of India for the dye which can be extracted from it; the flowers are small, of a greenish rose colour, and appear in the rains. *Clitoria ternatea* (Aparájitá), common everywhere in gardens; there are two varieties—the blue and the white. *Æschynomene aspera* (Sholá) grows on wet ground; the flowers are brownish orange, and appear in the rains; the wood of larger plants is particularly light, white, and spongy; it is gathered during April and May, and used for toys, floats for fishing, sun-hats, &c. *Lablab vulgare* (Shim), of which there are several

varieties, also belongs to this sub-order; also *Desmodium gyrans* (Ban-chárál); *Cicer Indica* (Bút-kalay, cholá); *Ervum lens* (Bar-masúr); *Ervum hirsutum* (Chhotamasúr); *Pisum sativum* (Matar); *Lathyrus sativus* (Khe-sári); *Abrus precatorius* (Kúch), the seeds are red with a

Fig. 118.

*Poinciana pulcherrima.*

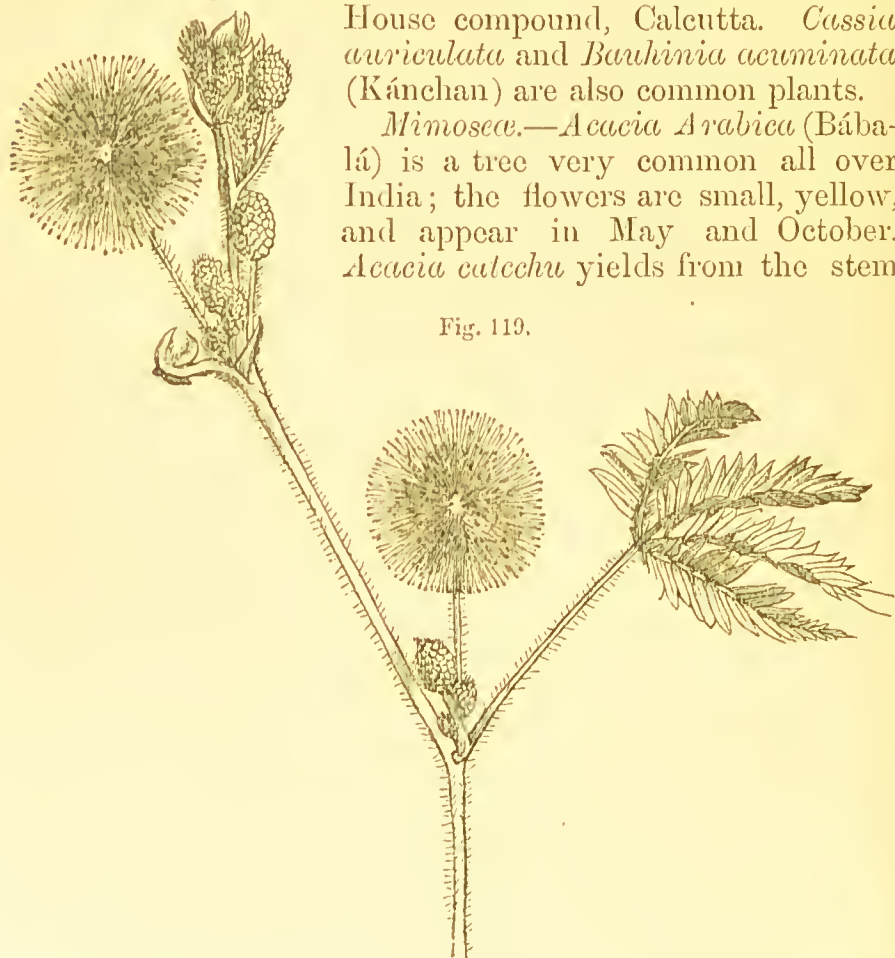
black eye, constantly used as a 2-grain weight; *Phaseolus mungo* (Háli-múg); *Dolichos sinensis* (Bar-bati); *Cajanus Indicus* (Arar); *Erythrina Indica* (Pálitá-mandár); *Dalbergia Sissoo*.

Casalpinia:— One of the commonest trees in India. *Tamarindus Indica* (Tintari) belongs to this sub-order; the flowers appear in May; they have only three stamens. *Poinciana pulcherrima* (Krishnachúra) is also very common; it is in flower and fruit all the year. *Poinciana regia* is largely cultivated everywhere; its bright scarlet and yellow flowers are very showy, and with its handsome foliage,

presents a gorgeous appearance when in full flower in the hot weather and rains. *Cassia fistula* is a small tree, with pendulous racemes, of bright yellow flowers, and long cylindrical indehiscent pods. *Cassia alata* (Dád-mardan) has large yellow-orange, strongly scented flowers, which appear in September and October: the fresh leaves are frequently used as a cure for ringworm. *Saraca Indica* (Ashok) is one of the most beautiful trees in India; the flowers are orange-scarlet; they appear in March and April; there is a very handsome row of them round Government House compound, Calcutta. *Cassia auriculata* and *Bauhinia acuminata* (Kánchan) are also common plants.

Mimoseae.—*Acacia Arabica* (Bábalá) is a tree very common all over India; the flowers are small, yellow, and appear in May and October. *Acacia catechu* yields from the stem

Fig. 119.

Sensitive plant—*Mimosa pudica*; natural size.

the astringent substance called catechu. The bark of most

of the *Acacias* is astringent. The fruit of *Acacia rugata* (Rítá) is used as a soap. *Acacia farnesiana* (Gúyá-bábalá) has small, yellow, fragrant flowers; the wood is tough, and is used in making native ploughs. *Mimosa pudica* (Ná-jak) (Fig. 119) is commonly called the sensitive plant; when touched or shaken, the leaflets fold together, the partial petioles approach each other, and the rachis, or main petiole, sinks down.

This order, which contains about 7,000 species, is further subdivided into several tribes founded upon the degree of cohesion of the stamens, the nature of the pod, leaves, habitat, &c. The *Papilionaceæ* are most universally distributed. The *Cæsalpinieæ* and *Mimoseæ* are chiefly tropical; the latter also abound in Australia, where the genus *Acacia* is more largely developed than in any other country. A large proportion of its species have leaves wholly destitute of a blade, being reduced to a petiole, which is much flattened and leaflike, serving the purpose of an ordinary leaf-blade. Some of these *Acacias* are naturalized in Southern India.

Rosaceæ

Are herbs, shrubs, or trees, with usually alternate stipulate leaves and regular flowers; stamens numerous, springing from the calyx; ovary of one or more free, or afterwards uniting, carpels; seeds one or few in each ovary, without endosperm.

This order is closely allied to Leguminosæ; the posterior position of the odd sepal is the only constant point of difference; from Myrtaeæ they are distinguished by the usually alternate stipulate leaves. With Anacardiaceæ they have some affinities, but the plants of this order are generally recognized by their resinous juice and their want of stipules. In India, Rosaceæ does not include many species of much economic importance, chiefly from the arrangement and number of the carpels and their position relative to the tube of the calyx. This order may be divided into three sub-orders: 1st, *Roseæ*, which has numerous free carpels, and to which the genera *Rosa* (Kánta-goláb), *Rubus* (Brambles), and *Fragaria* (Strawberry) belong; 2nd, *Drupaceæ*, having a single free carpel and drupaceous

fruit, to which belong the genera *Amygdalus* (Peach) and *Prunus* (Apricot); and 3rd, *Pomea*, with an inferior ovary, having one or more carpels adherent to the calyx tube, and to which belong the genera *Eriobotrya* and *Pyrus* (Apple).

The plants of this order are mostly natives of the temperate parts of the northern hemisphere, but are widely spread in cultivation.

The petals of several species of *Rosa* yield the essential oil called "attar of rose;" it is chiefly manufactured in Turkey, but a small quantity is produced at Ghazipore from the petals of *Rosa damascena*; it is frequently adulterated in India with the oil of *Andropogon*. *Kousso* is the dried flowers and leafbuds of *Brayera anthelmintica*, imported from Abyssinia.

Crassulaceae

Are succulent herbs with usually symmetrical flowers; carpels opposite the petals, often with a glandular scale at the base outside; distinct, or more or less coherent; seeds very small, with fleshy endosperm.

These plants are able to resist long droughts, because they store up large quantities of water, and their epidermis is of such a nature that evaporation from the surface is exceedingly slow; they are remarkable for their succulent foliage, and for the power of subsisting for a considerable time almost entirely on atmospheric elements; they are exceedingly

Fig. 120.



Leaf of *Bryophyllum calycinum*, with young plants on its margin.

tenacious of life. *Bryophyllum calycinum* is an erect plant, with opposite, simple or compound, leaves, and

large terminal panicles, of greenish purple, regular flowers; it was introduced into the Honorable Company's Garden, Calcutta, by Lady Clive in 1799, and from there has spread all over Bengal; the detached leaves are capable of pro-

ducing adventitious buds on their margins. *Kalanchoe laciniata* has small bright yellow flowers. The plants of this order are generally found in dry situations outside the tropics; they are especially abundant at the Cape of Good Hope. Several species are found in the Himalayas.

Myrtaceæ

Are trees or shrubs with usually opposite entire leaves, beset with resinous or translucent glands; calyx and corolla

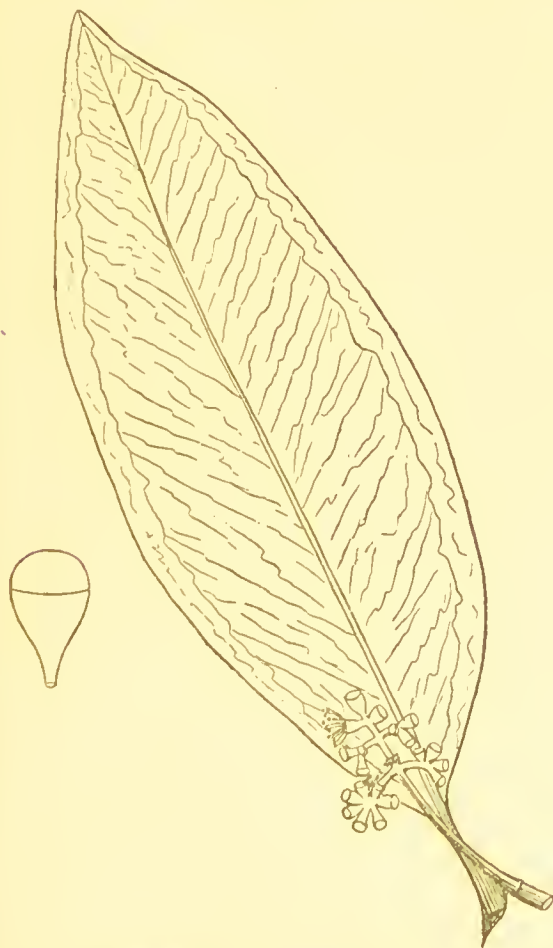
Fig. 121.

imbricated; stamens often numerous; ovary inferior, 2 to many-celled, with axile placentation; seeds usually indefinite, without endosperm.

The inferior ovary separates this order from Lythraceæ, and the simple inappendiculate anthers from Melastomaceæ. In Onagraceæ the petals are contorted. *Syzygium*

Syzygium Jambolanum (reduced).

lanum (Kâla-jâm) is a tree common everywhere, with opposite entire shining exstipulate leaves and panicles of



greenish white flowers, which appear at the beginning of the hot season; the petals are deciduous.

Fig. 122.



Psidium pyrifera (reduced).

Psidium pomiferum and *P. pyrifera* (Peyará), the red and white guava, are domesticated in India from tropical America. *Eugenia Jambos* (Goláb-jám) is common in gardens in most parts of India; the flowers appear in February, and are of a greenish white colour.

Myrtus communis (Biláti-mendí) is common in gardens everywhere; it flowers during the cold season. *Caryophyllus aromaticus* (Lavangá) is cultivated in Ceylon, the southern parts of India, the Malayan Peninsula, &c., for its dried unopened flower-buds (cloves). Like the Jambolan, the petals are deciduous, falling off as the stamens unfold. In the Australian genus, *Eucalyptus*, the lobes of the calyx-limb are coherent, and are thrown off in a similar manner as a lid. Some of the species of this genus have been introduced into this country, and planted in marshy places and swamps with apparently good effect. The dried fruit of *Pimenta vulgaris* is imported from the West Indies under the name of "Allspice."

Other genera are: *Eugenia*, L.; *Melaleuca*, L., &c.

Melastomaceae

Are herbs or shrubs with opposite entire, usually 3-nerved, leaves; petals imbricated, often oblique; stamens definite, with remarkable appendaged anthers, bursting by pores at the apex.

The most striking character of the flowers are the stamens with their oddly beaked anthers. *Melastoma malabathricum* (Baraphútikâ) is a large shrub having opposite, short-petioled, broad lanceolate leaves, from 3 to 5-nerved, with adpressed flat bristles and large regular terminal red flowers. The order derives its name from the genus *Melastoma* (black mouth), the fruit staining the mouth black.

Many of these plants are distinguished at first sight by the large curved ribs running from the base to the apex of the leaves.

The members of this large order are generally diffused within the tropics, but are most abundant in America; they are of very little economic use.

Other genera are: *Centradenia*, Don.; *Medinilla*, Gaudich, etc.

Lythraceæ

Are herbs, shrubs, or trees, with mostly opposite entire leaves and no stipules; calyx valvate; petals corrugated; stamens definite; ovary free; seeds numerous, without endosperm.

This order is distinguished from *Myrtaceæ* by its free ovary and valvate calyx; the superior ovary also distinguishes it from *Onagraceæ* and *Melastomaceæ*. *Lagerstræmia Indica* (Telángá-chiná) is a shrubby plant, with nearly opposite oval leaves and white, rose-coloured or purplish flowers; the petals have long claws, and are much curled; the stamens are unequal. *Lagerstræmia Flos-reginæ* (Járúl) (Fig. 123, see next page) is a tree with opposite oblong leaves and equal stamens; calyx variously grooved on the outside; the flowers, which appear in the hot season, are large and handsome. *Lavsonia inermis* (Mendi) is a large shrub, in flower and seed most part of the year; the flowers are small greenish white, and very fragrant; it is much used for hedges; the fresh leaves, beaten up with catechu, dye the nails and skin of a reddish orange colour, which is much admired by the women of India; the nails of Egyptian mumunies are sometimes found dyed with it. *Woodfordia floribunda* (Dháephúl) is a very beautiful flowering shrub or small tree; it flowers during the cold and beginning of the hot season. *Ammannia vesicatoria* (Dádnári): the leaves of this plant are

highly acrid, and are sometimes employed to raise blisters in rheumatism.

Fig. 123.



Lagerstræmia Flos-reginæ.

Punica granatum (Dálim-ánár) (Fig. 124), has a peculiar succulent berried fruit, called a balausta, in which the pulpy cells are arranged in two superposed series, some of which are in the centre round the axis, others are placed outside; all being adherent to the calyx. A transverse section, through the lower part of the fruit, shows three carpellary

divisions, with ovules situated on projecting central placentas.

Fig. 124.

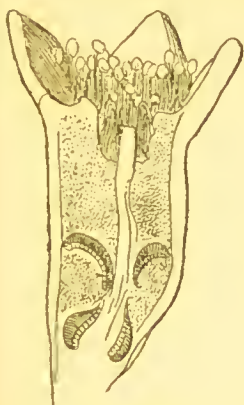
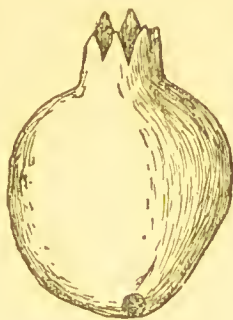
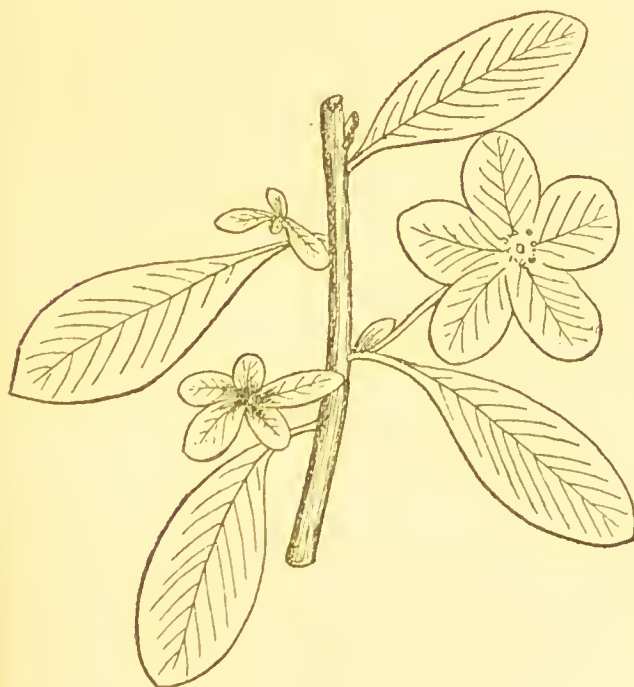


Fig. 125.



Punica granatum. Pomegranate (reduced).
the root-bark is used for the destruction of tapeworm.

Fig. 126.



Jussiaea repens.

A transverse section, through the upper part, shows five carpellary divisions, with ovules attached to placentas projecting inwards. The real nature of the structure may be conceived by comparing it with the excavated receptacle of the rose. The rind of the fruit is astringent; a decoction of

Onagraceae

Are herbs or shrubs with usually 4-merous flowers; calyx valvate; corolla contorted; stamens definite; ovary 2 to 4-celled, inferior; seeds numerous, without endosperm.

The parts of the flower in this order are almost invariably 4-merous. *Jussiaea repens* (Kesará-dám) is an annual herb

found in most parts of India floating on lakes and pools of

fresh water; in flower during the rainy season; the floats of cellular tissue attached to the submerged nodes are peculiar; this plant is exceptional in having the parts of its flowers usually in fives. *Ludwigia parviflora* (Ban labangá) is a small resinous plant, flowering in the rainy season; flowers small, yellow. *Trapa bispinosa* (Páníphal) is a plant found floating in stagnant water; it flowers during the rains; the flowers are pure white, expanding above the surface of the water late in the afternoon; the petioles are inflated, and act as floats; the fruit is triangular, armed with two strong barbed spines from the upper angles: the seeds contain unequal cotyledons.

Other genera are: *Enothera*, L.; *Clarkia*, Pursh.; *Lopezia* Cav.; and *Fuchsia* Plum., etc.

Rhizophoraceæ

Are trees, rarely shrubs; natives of salt swamps and marshes, where they root in the mud, forming dense, most unhealthy, jungles down to the very edge of the ocean. The leaves are opposite stipulate; calyx valvate; petals

Fig. 127.



Rhizophora mucronata.

often fringed; stamens definite; ovary more or less adherent; seeds without endosperm; germinating and forming a long root before the fruit falls from the tree.

The striking feature of this order is the germination of the seeds within the fruit while yet attached to the tree; the radicle emerges from the

apex of the fruit. *Rhizophora mucronata* (Bhorá) is a

native of the delta of the Ganges, where it grows to be a tree of considerable size; the flowers are white, sweet scented, and appear in April and May. The bark of the plants of this order is usually very astringent.

Other genera are: *Bruguiera* (Kánkrá), *Ceriops*, Arnott (Garán); *Kandelia*, W. and A.; and *Carallia*, Roxb.

Combretaceæ

Are trees or shrubs with opposite or alternate simple leaves; stamens mostly 10; ovary inferior, 1-celled, with pendulous ovules; seeds without endosperm.

The unilocular 1-seeded fruit distinguishes this order

Fig. 128.



Quisqualis Indica (reduced).

from its nearest allies. *Quisqualis Indica*, the Rangoon creeper, is a large scandent shrub, with the young shoots very downy, and with opposite, or nearly opposite, simple entire leaves, and terminal and axillary spikes of slender reddish flowers, remarkable for their long calyx-tubes. *Terminalia Catappa* (Bádám) is a beau-

tiful large tree, the branches of which spread horizontally; the flowers are small, purplish green; they appear in the hot season; the wood is good; and the kernels of the

fruit are eaten as almonds: the fruits of other species of *Terminalia*—*T. bclerica* (Bahará) and *T. Chebula* (Hárítakí)—are astringent. Many of the plants of this order are valuable timber-trees, and a number are cultivated on account of their flowers.

Other genera are: *Combretum*, Löfl.; *Poirrea*, Commers.; *Getonia*, Roxb.; *Anogeissus*, D. C. (common in Southern India); and *Lumnitzera*, Wild.

Passifloraceæ

Are herbaceous or shrubby plants, climbing by tendrils; flowers hermaphrodite, numerous; filamentous processes spring from the tube of the corolla forming what is termed the corona; stamens 5, monadelphous; ovary 1-celled, superior.

These plants are most numerous in tropical (*i.e.*, including Central) America and the West Indies.

The superior ovary, the presence of endosperm, the coronet, and the gynandrophore bearing, the stamens and ovary, mark this order out very clearly. *Passiflora quadrangularis* is a tropical American plant, common in gardens; the flowers are large whitish rose-coloured, variegated with blue. The beauty of the flowers and foliage render this order a favourite one for cultivation. *Modecca trilobata* is common in Chittagong; the flowers are yellow, and they appear in September and October. The corona of Passion flowers is an outgrowth from the flower tube at the base of the petals.

Cucurbitaceæ

Fig. 129.



Section of Cucumber, showing the construction of the ovary.

Are mostly succulent herbaceous plants, prostrate or climbing by tendrils; flowers monœcious or dicecious; stamens from 3 to 5, often united by their sinuous anthers; ovary inferior, 3-celled; fruit a pepo; seeds mostly flattened, without endosperm.

These plants form a very well defined order. From *Passifloraceæ* they are distinguished by their inferior ovary, unisexual flowers, peculiar anthers, and the absence of endosperm. They differ

in habit, floral envelopes, and definite stamens from the Begonias. The tendrils of this order are generally regarded as partially metamorphosed leaves. The andrœcium has, by some persons, been considered to consist of five stamens with unilocular anthers united into three bundles; other Botanists believe there are three stamens, one with a 1-celled anther, and two with 2-celled anthers. The construction of the ovary is peculiar, as, though the placentas are termed parietal, they are rather an excessive case of the inflexion, which ordinarily produces axile placentation.

The plants of this order especially abound in India. *Momordica Charantia* (Karalá): flowers middle-sized, yellow; the fruit is small and rough coated. *Momordica muricata* (Ochyá), a variety of *M. Charantia*, is very largely cultivated; the flowers are pale yellow. *M.*

Fig. 130.



Male and female flowers of
Cucumis melo.

dioica is also largely cultivated. *Cucumis melo* (Khurbuj), *C. sativus* (Susa), *C. utilissimus*, a variety of *Melo* (Kankoor), have all much appreciated fruits. *Cucurbita maxima* (Sulphuree kúmrá) is the common gourd; the flowers are very large, yellow, and appear in the rains and cold season. *Ce-*

phalandra Indica (Telakoocha) grows wild in every hedge, and seems to thrive equally well in every soil; the fruit is red when ripe, and is greedily devoured by birds. *Citrullus vulgaris* (Tarmuj) has large yellow flowers, which appear in January and February; the fruit is sometimes known as the watermelon. The pulp of *C. Colocynthis* furnishes "Colocynth." *Benincasa cerifera* (Kúmrá), pumpkin, has large yellow flowers; the fruit is universally eaten. *Lagenaria vulgaris* (Láo), the bottle gourd; the flowers

are large, white; the hard rind of the fruit is used as a bottle, and for making a kind of stringed instrument termed sitár. *Trichosanthes anguina* (Chichinga) has a

Fig. 131.

Fruit of *Luffa pentandra* (reduced).

large white flower, which appears in the rains. *Luffa pentandra* (Dhúndúl) has large yellow flowers; the fruit forms a kind of pyxidium by the separation of the scar of the calyx, the upper part falling off like a lid by circumscissile dehiscence. *L. aegyptiaca* (Jhingá) has large yellow flowers, which open about 4 P.M. to 5 P.M.; the fruit is largely used as a vegetable.

The form of the

fruits of this order is varied; it may be oval, globular, bottle-shaped, and even snake-like in form; some kinds are dehiscent. In *Momordica* and others, it bursts irregularly; and in *Ecballium agreste*, which furnishes "Elatarium," the fruit bursts by separating from the peduncle.

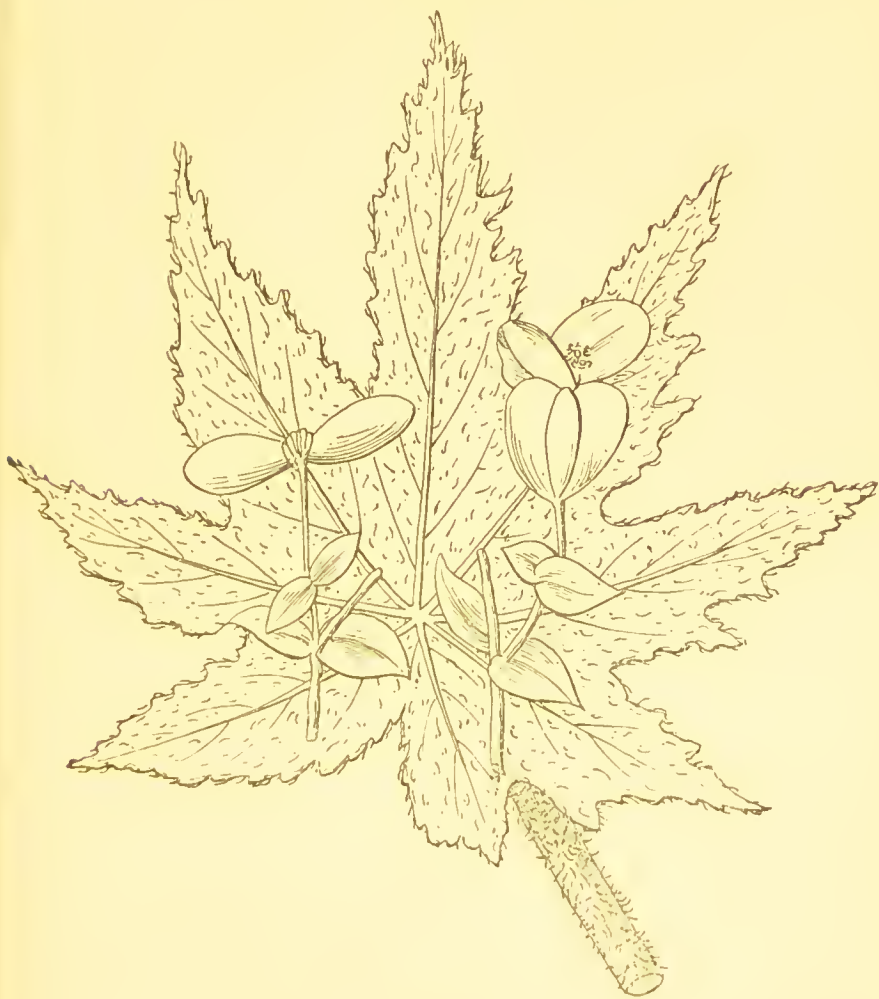
Begoniaceæ

Are succulent herbs with alternate leaves, often oblique at the base; flowers monœcious; stamens indefinite; stigmas sinuous; ovary inferior, 3-celled; fruit capsular; seeds without endosperm, on forked placentas.

The unequal sided leaves are characteristic of this order, whence they are called elephants' ears. The perianth segments are usually all petaloid. The species of this family nearly all belong to the genus *Begonia*; the silvery appearance of the leaves in some of them is owing to a film of air under the epidermis; the stomata are frequently collected in clusters. *Begonia* (any species) are herbs, with

alternate stipulate, obliquely cordate, leaves, and axillary 2-flowered peduncles, of pale pink, white, yellow, or deep red unisexual flowers. Many *Begonias* are remarkable for the production of adventitious buds from various parts of their surface.

Fig. 132.

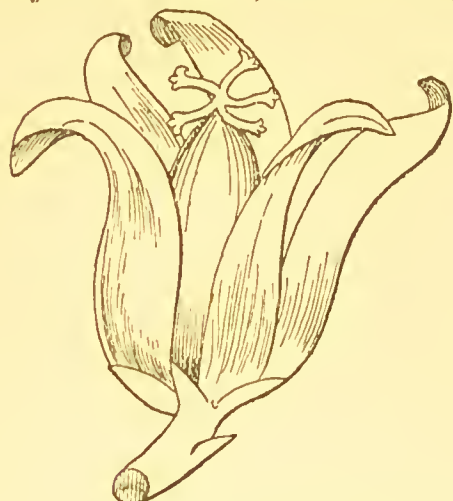


Begonia.

Papayaceæ

Are trees or shrubs, sometimes with an acrid milky juice,

alternate, lobed, long-stalked leaves, and unisexual flowers; ovary free, 1-celled; seeds endospermic.



Female flower of *Carica papaya*.



Fig. 134.

Male flowers of *Carica papaya*.

Fig. 133.

This order stands near *Cucurbitaceæ* and *Passifloraceæ*: from the first it is distinguished by its free ovary, and from the latter by its usually unisexual flowers without a corolla. Bentham and Hooker include it under *Passifloraceæ*.

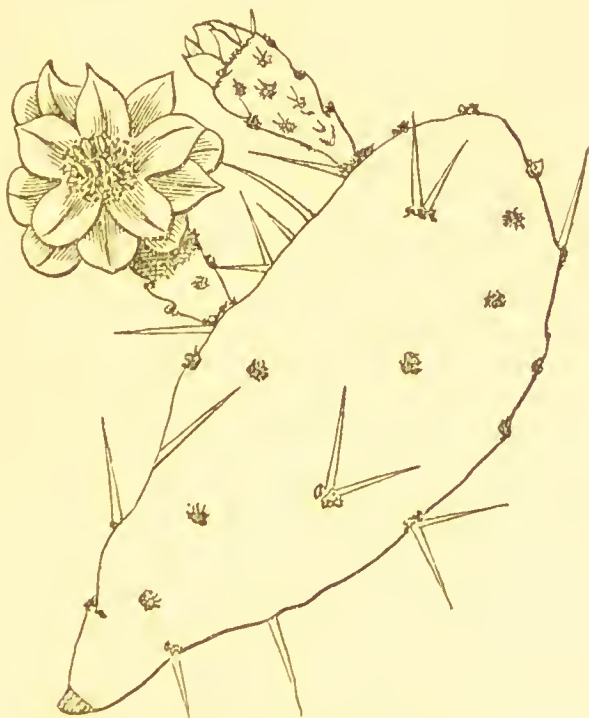
Carica papaya (Pepiyá), a tree domesticated from South America, is cultivated in gardens all over India for the sake of its fruit; the female and male flowers are produced on different trees; the latter in very large numbers; fertilization is probably aided by wind, though insects undoubtedly assist in the process. The milky juice of the unripe fruit is sometimes used in medicine.

Cactaceae

Are mostly leafless plants (or only furnished with scale-like leaves), with fleshy and thickened stems of peculiar aspect, usually armed with prickles; flowers solitary, sessile; the calyx and corolla generally undistinguishable and imbricated in numerous rows, adherent to the 1-celled ovary, with parietal placentas; stamens indefinite; style multifid.

These plants are almost exclusively found in the dryer parts of tropical America, ascending into temperate regions in the mountains. They are generally distinguishable at first sight by their peculiar succulent stems and the absence of true leaves. *Opuntia dillenii* (Nágphená), from

Fig. 135.

*Opuntia dillenii* (reduced).

South America, is now domesticated all over India; the stems are jointed, oblong, and much compressed; the thorns generally simple, long, and straight, issuing from tufts of sharp bristles; the flowers are large, yellow, and appear

chiefly during the hot season, and more or less during the rest of the year. *Cereus triangularis*, from Mexico, is now found in many parts of India growing epiphytic on large trees. *Cereus hexagonus* is also very common; it belongs to the columnar modification. The globular *Echinocactus* is occasionally cultivated as a curiosity. A species of *Rhipsalis* occurs in Ceylon.

Umbelliferae

Are herbs usually with fistular stems and alternate exstipulate, generally deeply divided, leaves, sheathing at the base; flowers in umbels; stamens 5, epigynous; styles 2; carpels (mericarps) 2, separating when ripe, dry, indehiscent, remaining attached above to an entire, bifid or bipartite *carpopophore*; the pericarp develops longitudinal ridges (*juga*), with intervening depressions (*vallecule*), in which frequently are formed oil-bearing channels called *vittæ*.

This order is of small importance in Indian botany: it is most abundant in the northern and central parts of Europe, Asia, and America, and is also common at high elevations on the Himalayas. The most important qualities of this order are the aromatic oils developed in the *vittæ* of the mericarp, and the medicinal resinous substances found in other parts of the plant.

The essential character of the order lies in the fruit, by which it is distinguished from all other families. *Daucus carota* (Gájar) is found only in a cultivated state in India; it flowers during the cold season. *Coriandrum sativum* (Dhányá) is a herbaceous plant, with an erect hollow stem, and alternate, sheathing, much-divided leaves, and small white flowers in terminal compound umbels, which appear during the cold season. *Peneclanum graveolens* (Sulphá) is cultivated for its aromatic seeds; the flowers are small, yellow, and appear in February. *Fœnieulum vulgare* is also cultivated for its seeds, which have a pleasant, sweet, warmish taste. *Hydrocotyle Asiatica* (Thaleúrí) is a common creeping plant, found in moist shady places; it has long petioled reniform crenate leaves; the flowers are in simple umbels, small, purplish red, and appear during the rains and cold season; this plant is very widely distributed,

being found in Africa, South America, and Australia. *Pimpinella involucrata* (Rándhani): the seeds are aromatic, pungent. *Seseli Indicum* (Hanjoan), found in shady moist places; the seeds are used as a medicine for cattle. *Carum carvi* (Caraway) grows abundantly at high elevations in the Himalayas and throughout Europe and temperate Asia. *Carum copticum* is much cultivated in India for its aromatic oil.

Other genera are: *Anethum*, L.; *Ferula*, L. (Assafoetida); *Dorema* (Ammoniacum); *Conium*, L.; and *Cuminum*, L.

Araliaceæ

Are trees, shrubs or herbs, with alternate simple or compound leaves; petals and stamens epigynous; styles usually more than 2; fruit 3 or more-celled, usually succulent, with one endospermic seed in each cell.

The Araliaceæ are distinguished from Umbelliferae, their nearest allies, by the ovary having more than two carpels which do not separate in the fruit, but become drupaceous or baccate, and in having fleshy, in place of horny, endosperm. *Panax fruticosum* is a shrub cultivated in most gardens, with decompound leaves; leaflets lanceolate, acutely serrate; umbels globular, in terminal panicles; the flowers are small, brownish green, and appear in May and June. *P. pseudo-ginseng* is a native of Nepal, and is closely allied to *P. ginseng*, which yields the famous Ginseng of the Chinese, used as a restorative. *Hedera Helix*, L., common in Britain, is likewise a native of the Himalaya and Khasia mountains. The substance called rice-paper, prepared by the Chinese, consists of thin sheets of the pith of a species of *Fatsia*. *Paratropia venulosa* is a small tree, with alternate digitate smooth leaves, and numerous umbels of very small flowers, arranged in terminal panicles.

Rubiaceæ.

Are herbs, shrubs, or trees, with opposite entire leaves and interpetiolar stipules, or with verticillate leaves; calyx adherent to the 2 to 4-celled ovary; stamens as many as the corolla, epipetalous; ovules anatropal; seeds perispermic.

The presence of interpetiolar stipules, either small

Fig. 136.

*Ixora coccinea.*

or resembling leaves, is one of the principal characters of this order; the inferior ovary distinguishes it from Loganiaceæ. *Ixora coccinea* is a shrubby plant about three feet high, with oblong, cordate, sessile, acute, smooth, entire leaves, and terminal dense clusters of bright scarlet flowers, which

appear all the year round. *Ixora Bandhuca*, a variety of *coccinea* (Rangan), is a ramous bushy shrub with opposite stem clasping, oblong, obtuse, entire, smooth leaves, with a small terminal point; flowers numerous, scarlet, changing to crimson. *Gardenia florida* (Gandharaj) is a large, very ramous, shrub, with large white fragrant flowers, which are often double from a multiplication of the cohering petals and change of stamens into petals. *Anthocephalus cadamba* (Kadam) grows to be a large tree; flowering time the hot season; the flowers form a large, perfectly globular, orange-coloured head, with the large white clubbed stigmas projecting. *Mussaenda macrophylla* is striking on account of the foliaceous development of one calyx lobe. *Ixora pavetta* (Kúkúrchúra) is a middle-sized shrub common on roadsides, hedges, uncultivated land, &c., where there is a good soil; the flowers are white, somewhat fragrant, and appear in April and May. *Coffea Arabica* is a shrub, with oblong ovate acuminate leaves and axillary white flowers. Coffee consists of the horny

endosperm of the seeds, which are produced in a succulent berry. *Rubia cordifolia* (Mandista): root perennial; stems scandent, climbing over trees and bushes: the roots, stems, and larger branches are used as a red dye (Indian madder). The most important genus of the order is *Cinchona*, of which there are many species indigenous

Fig. 137.



Flowers of Cinchona.

in South America, from which the valuable febrifuge *Quinine* is obtained; the plants were originally procured from the slopes of the Andes at an elevation of about 7,000 to 8,000 feet. A large number of these trees are now grown in the Government plantations

near Darjiling, the great majority of these plants are of the *Succirubra* species. The *Calisaya* species and other hybrid varieties are also cultivated. *Cinchona* is also grown on the mountains in Southern India. *Hedyotis racemosa* (Gandha bhádálí): the flowers are small, white, and appear in the rainy season.

The Rubiaceæ form a very extensive group, and are often divided into two orders—Cinchonaceæ and Stellatæ; the former are chiefly natives of warm climates, most of them tropical; the Stellatæ belong mainly to the northern and the mountains of the southern hemisphere. Many of the commonest tropical weeds belong to this order.

Ipecacuanha is the root of a Brazilian species of *Cephalis*. *Gambir* is an astringent extract obtained from the leaves of *Uncaria Gambir* of the Malayan Peninsula.

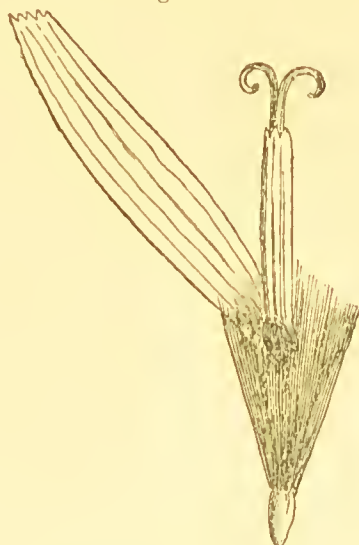
Compositæ

Are herbs or shrubs with alternate or opposite leaves, with the flowers in dense heads, upon a common receptacle,

surrounded by an involucre; stamens usually 5; anthers syngenesious; ovary inferior, 1-celled, with one erect ovule; seeds without endosperm.

This order, which is the most numerous in genera and

Fig. 138.



Ligulate floret of *Compositæ*.

species, and by some authors regarded as the most perfect in the vegetable kingdom, is likewise very natural; its distinguishing features being very evident in almost every genus. The Linnæan class, Syngenesia, corresponds to Compositæ.

This extensive order is divided into the three sub-

orders:—

First.—*Tubulifloræ*. The central or all of the flowers are tubular, hermaphrodite, with 5, rarely 4, equal teeth. *Vernonia cinerea* (Koksim): this plant is one of the most common in every part of India, and it is in flower all the year; the flowers are small, light purple, and the pappus is hairy. *Vernonia anthelmintica* (Somraj) is an erect annual, commonly found on high uncultivated ground or rubbish; it flowers during the cold season. *Adenostemma leiocarpum* (Barakeshuti): stem below resting on the ground, above erect, round, very slightly hairy; from two to four feet long; the flowers are small, white, and appear in February and March. *Eclipta erecta* (Keshúri) has small white flowers; it flowers the whole year. *Zinnia elegans*, a common garden annual imported from America, with opposite entire leaves and terminal solitary heads of variously coloured florets. *Wedelia calendulacea* (Keshráj) is a creep-

ing perennial, with opposite broad lanecolate serrate leaves, and bright yellow flowers, which appear in the rains. *Enhydra Heloncha*, a native of Bengal, growing in moist rich soil; flowering time the cold and hot season; florets white, the achenes invested by the paleæ, each surrounded by an involuere (Syngenesia segregata). *Calendula officinalis* (Marigold), domesticated in India; it flowers during February and March. *Pyrethrum Indicum* (Chandramulika) is common in gardens; the flowers are yellow. *Carthamus tinctorius* (Kúsúm): flowers deep orange; it is cultivated in India for the dye obtained from it, as also for the oil got from the seeds. *Verbesina elongata* is a very common plant growing on walls, the flowers are yellow.

Second.—Labiatifloræ. Flowers usually 2-lipped, or deeply 5-partite. *Gerbera* and a few other genera are represented in the Himalayas, but most of this sub-order are South American.

Third.—Ligulifloræ. All the flowers are hermaphrodite and ligulate. *Sonchus oleraceus* (Ban-palang), an annual growing on rubbish, with an erect stem from three to six feet high; flowers numerous, large, yellow; they appear during the latter part of the cold season.

The species are more numerous than those of any other order; more than 10,000 being known. The *Tubulifloræ* are most abundant in hot, the *Ligulifloræ* in cold, climates; the *Labiatifloræ* being almost entirely confined to extra-tropical South America; bitterness is the prevailing quality of the order.

Other genera are: *Anthemis*, L.; *Artemisia*, L.; *Arnica*, *Berthelotia* *Notonia*, D.C.; *Cacalia Eupatorium*, Tournef; *Aplotaxis*, D.C.; *Chrysanthemum*, L.; *Blumea*, D.C.; *Taraxacum*, Hall; *Lactuca*, Tournef, &c.

Plumbaginaceæ

Are herbs or dwarf, and usually spiny, rarely climbing, shrubs, with regular 5-merous flowers; the five stamens superposed to the petals or lobes of the corolla; ovary 1-celled, with five styles; ovule solitary.

The position of the stamens and number of styles sepa-

rate this order from its nearest allies. *Plumbago zeylanica*

Fig. 139.



Plumbago zeylanica.

(Chitá) is a shrubby garden plant, with alternate simple leaves and long viscid hairy spikes of regular white, pale blue, or rose-coloured flowers. Preparations of the root are used in medicine (tita).

Most of the species of this order are sea-coast or salt marsh plants, or natives of the saline plains to the north-west of India.

Myrsinaceæ

Are trees or shrubs with alternate simple leaves and regular flowers; stamens 4 to 5, opposite the lobes of corolla; ovary 1-celled, with free central placenta.

This order represents the *Primulaceæ* in hot climates; between them no absolute distinctive character can be drawn, excepting that the *Myrsinaceæ* are, as a rule, shrubs or trees with more or less succulent fruits, while the *Primulaceæ* are herbs with dry capsular fruits. *Ardisia humilis* (Banjam) is a small tree or large shrub, a native of moist places; in flower and seed nearly the whole year; the leaves are alternate, smooth, entire; and the flowers are of a pale rose-colour, arranged in axillary racemes. *Ægieceras majus* (Halsí) is a small tree, a native of the delta of the Ganges and such other places as are overflowed at spring-tides; flowering time the hot season.

Other genera are: *Badula*, Juss; *Myrsine*, L. R. Br.; *Embelia*, Forsk, and *Mesa*, Juss.

Ebenaceæ

Are trees or shrubs with alternate entire leaves and regular dioecious flowers, often with numerous stamens free from the corolla; fruit a several-celled berry; seeds endospermic.

This order differs from the *Sapotaceæ* by the hardness of its wood and the absence of milky juice, by the cells of the ovary being 2-ovulate, &c.: the plants are distributed mostly in tropical India. *Diospyros cordifolia* (Ban-gáb), a tree found over most parts of India, with

alternate simple leaves and drooping dioecious small greenish-white flowers. *Diospyros tomentosa* (Tamál), a native of the northern parts of Bengal, where it grows to be a tree of great size; the wood is black, hard, and heavy; the flowers are small, whitish, and appear in March and April. *D. embryopteris* (Gáb), the viscid juice of this tree is sometimes rubbed on the bottom of boats, to keep them watertight; fishing-nets are occasionally steeped in an infusion of it, to render them more durable.

Other genera are: *Royena*, L.; and *Maba*, Forst.

Styraceae

Are trees or shrubs with simple alternate leaves, and usually hermaphrodite flowers; stamens numerous, epipetalous; ovary 2 or more celled; cells 1-ovuled.

The flowers of this order frequently have an adherent calyx, a simple style, and a capitate stigma, which distinguish them from *Ebenaceae*. *Symplocos racemosa* (Lodh) is a small tree of from 12 to 20 feet high; flowering time the month of December; the flowers are usually solitary, small, of a yellow colour; the red powder used during the hoollee holidays is made from the bark of this tree. The gum Benzoin, used as medicine, is the balsamic resin obtained from *Styrax Benzoin*, a native of the Malayan Archipelago.

Sapotaceae.

Are trees or shrubs with alternate entire leaves and milky juice; flowers regular; stamens superposed and attached to the lobes of the corolla, alternate with scales or sterile stamens; anthers extrorse; ovary 2 to 12-celled; seeds endospermic.

This order differs from *Ebenaceae* in its milky juice and the wood being generally of a softer character, and by the usually hermaphrodite flowers, epipetalous stamens, and 2-ovulate cells of the ovary. *Mimusops elengi* (Bakúl) is a middle-sized ornamental tree, common in gardens, with alternate, entire, smooth leaves and axillary fascicles

of white fragrant flowers. *Achras sapota* is much culti-

Fig. 140.



Achras sapota (reduced).

vated for its luscious fruits, which have the appearance of old potatoes. *Bassia latifolia* (Mahúa) is a small sized useful tree, with alternate petioled leaves, crowded about the extremity of the branches; the flowers are white, and appear in March and April; they are sometimes eaten: the wood is hard, and very strong. The fruit of *Chrysophyllum Cainito* is known as the star-apple. *Isonandra gutta* is the tree from which guttapercha is obtained by evaporating the milky juice; it is a native of the Malayan Peninsula.

Other genera are: *Lucuma*, Juss; *Imbricaria*, Commers; and *Sideroxylon*, L.

Oleaceae

Are trees or shrubs, often with twining stems; leaves mostly

opposite ; stamens 2 ; ovary superior, 2-celled, with one to four ovules in each cell ; fruit a berry or capsule ; seeds with or without endosperm.

The two stamens alternating with the carpels distinguish *Oleaceæ* from nearly all gamopetalous orders with regular flowers. *Jasminum sambac* (Ban malliká) is a shrubby twining plant, with opposite subsessile leaves, common all over India ; the flowers are white, and delightfully fragrant ; there are three varieties of it—a single, and two double—all flower during the rains. *J. hirsutum* (Koondo) and *J. auriculatum* (Jooín) are common. *Nyctanthes arborescens* (Singáhar, Sialí) is a large shrub or small tree cultivated in gardens ; the flowers are very fragrant, honey-scented ; they open at sunset and fall off at sunrise ; the tube is orange-coloured, and the border white ; they are used as a dye. *Ligustrum robustum* is a tree with opposite entire leaves and panicles of small white flowers. *Olea Europæa* is one of the most important plants of the order, largely cultivated in Asia Minor, the south of Europe, and the Islands of the Mediterranean, for the bland oil expressed from the fleshy pericarp ; it is used in the preparation of medicine, and is also largely used for food in the countries bordering the Mediterranean, and in more northern countries in salads, &c. ; also extensively employed in the arts and manufactures.

Other genera are : *Fraxinus*, Tournef ; *Noronhia*, Pet. Th. ; *Chondrospermum*, Wall ; and *Ornus*, Pers.

Apocynaceæ

Are trees or shrubs, often climbing or twining, with entire, mostly opposite, exstipulate leaves ; flowers regular ; corolla twisted in the bud ; stamens 5, alternate with corolla lobes ; pollen granular ; ovary usually 2-celled, composed of two carpels, coherent or free in the ovaries and staminal region, and quite blended in the dumbbell-shaped stigma ; seeds endospermic, often comose or winged.

The nearest affinity is *Asclepiadaceæ*, from which they are chiefly distinguished by the freedom of the stamens

from the stigma and the granular pollen.

Fig. 141.



Vinca rosea (reduced).

white, delightfully fragrant flowers. *Beaumontia grandiflora* is a native of the hilly parts of Chittagong; the flowers are very large, white, with a greenish yellow throat. *Tabernaemontana coronaria* (Phirki-tagar), a shrub common in gardens all over India; it is in flower the greater part of the year; the flowers are pure white, and fragrant; there is a double variety, which is even more common than the single. *Alstonia scholaris* (Chatin), a tree common in forests throughout India; the flowers are small greenish white, the bark is a powerful tonic. *Plumiera acuminata* (Gobariya ehampá) is a large shrub, very common in gardens; the trunk is from six to ten feet high, branches numerous, three-forked, swollen towards the buds; the height of the whole tree from fifteen to twenty feet; leaves crowded about the ends of the branchlets; flowers numerous, succeeding one another for a great length of time; on the outside they are tinged with red, the inside pale yellow below, whitish above; fragrant, especially during the night. *Carissa Carandas* (Karamelhá)

Vinca rosea (Galphiringí) is a perennial, erect, ramous herb, with opposite entire leaves and axillary rose-coloured or white flowers in pairs; common in gardens in every part of India, and in flower the whole year. *Nerium Oleander* (Karabí), common in gardens; there are several varieties, double and single, white and red, &c. *Echites caryophyllata* (Gandha-málatí) has large, pure,

is a large common shrub, the branches are numerous, two-forked, rigid, smooth, and round; spines constantly in pairs at the divisions of the branches; flowers pure white, inodorous; the fruit is sometimes eaten. *Thevetia nerifolia* (Kalika) is a Mexican plant domesticated all over Bengal; the flowers are bright yellow, sweet-scented, and flowers throughout the year.

Other genera are: *Holarrhena*, R. Br.; *Ichnocarpus*, R. Br.; *Cerbera*, L.; *Ophioxylon*, L.; *Rhazya*, &c.

Asclepiadaceæ

Are shrubs or herbs, often twining, with milky juice and opposite entire exstipulate leaves; flowers regular; corolla mostly contorted, rarely valvate; stamens 5; stigma coherent into a 5-angled fleshy head, to which the anthers are adherent; pollen coherent into wax-like or granular masses; carpels 2, usually distinct in the ovary, united in the style and stigma; seeds with thin endosperm, often comose.

The curious organization of the stigma and pollen is

Fig. 142.



Calotropis gigantea (reduced).

the great distinguishing marks of this order, which in other respects is nearly allied to *Apocynaceæ*. *Calotropis gigantea* (Akanda): this is one of the most common herbaceous shrubs in India; it is in flower all the year round; it grows everywhere, but chiefly about old walls, hedges, and waste places: there are two varieties—the white and the purple—which differ only in colour; preparations of the plant are sometimes used in medicine, and the fibre of the bark is sometimes employed for textile purposes. *Hemidesmus Indicus* (Anantú-múl) is a common twining

shrub, with ovate to linear smooth shining leaves ; it flowers during the wet season ; the roots are used as a substitute for Sarsaparilla. *Tylophora asthmatica* (Antú-múl) is a perennial twining plant, common almost everywhere ; the roots are employed as a substitute for Ipecacuanha. *Dæmia extensa* (Chágal bántí) is a perennial twining herb, a native of hedges ; flowering time the wet and cold season ; the leaves are opposite, petioled, broad, cordate ; the flowers are of a pale green, internally tinged with purple. *Pergularia odoratissima* (Kanja-latá), a creeper common over Bengal and Burmah ; the flowers are on the outside whitish, inside of a greenish orange-colour, and delightfully fragrant. *Cynanchum pauciflorum* (Chágalpátí), a creeper common over the Peninsula of India ; the flowers are small, rust-coloured. Several species of this order are favourite garden flowers, especially *Stephanotis* and *Hoya Carnosa*, which has wax-like leaves and blossoms, sometimes very handsome. In the genus *Dischidia*, the leaves are sometimes converted into pitchers.

Other genera are : *Asclepias*, L. ; *Secamone*, R. Br. ; *Dæmia*, R. Br. ; *Gymnena*, R. Br., &c.

Loganiaceæ.

Trees, shrubs, or herbs, with opposite entire leaves and interposed stipules ; flowers regular ; stamens as many as, and alternate with, the corolla lobes ; ovary superior, usually 2-celled.

As Bentham has remarked, this order consists on the whole of *Rubiaceæ*, with a free ovary ; the main difference from *Apocynaceæ* and *Gentianaceæ* lies in the stipules. *Strychnos nuxvomica* (Kúchilá), a middling sized tree ; in flower during the cold season, with opposite oval shining smooth leaves, from 3 to 5-nerved ; flowers small, greenish white, collected in terminal cymose panicles ; fruit smooth, of an orange yellow colour, when ripe ; seeds several, immersed in the pulp, which is eaten by birds. Strychnine is an alkaloid obtained from the seed. *Strychnos potatorum* (Nirmmalí), a tree larger than *Nuxvomica* ; the flowers are greenish yellow ; the ripe seeds are dried, and sold in every bazar for the purpose of clearing muddy-water ; the impurities settle to the bottom when such water is poured into vessels which have been rubbed out with one

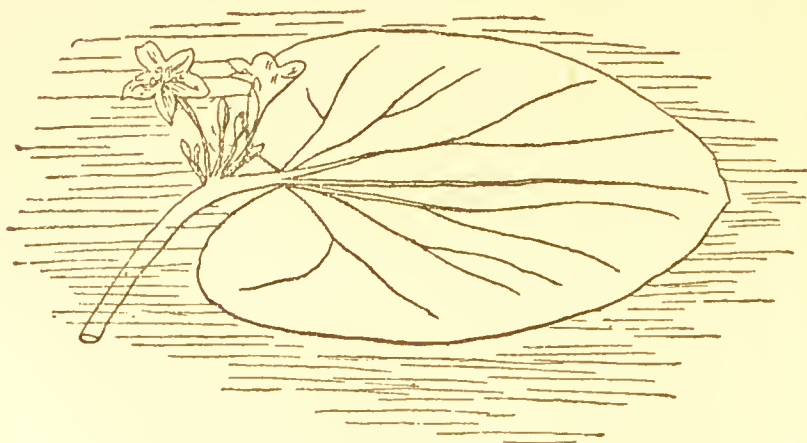
of the seeds. *Fagraea fragrans*, a tree growing in China and the Malayan Peninsula, the bark of which has been found effectual in the treatment of malarious fevers.

Gentianaceae

Are herbs, or rarely shrubs, with bitter juice and opposite entire exstipulate leaves, or aquatic plants with floating alternate leaves; flowers regular, with a persistent calyx; stamens as many as, and alternate with, the lobes of the corolla; ovary 1-celled, with two parietal placentas and indefinite ovules; seeds with copious endosperm.

The parietal placentation, the coherent carpels, and the want of milky juice separate this order from *Apocynaceae*, its nearest ally. *Exacum tetragonum* (Kúcharí) is an erect annual herb, with sessile lanceolate, 5-nerved leaves, and numerous terminal beautiful blue flowers; it grows amongst long grass, and flowers during the rains; in the ovary, the placentas project into the cavity, and meet, so as to make it almost completely 2-celled. *Villarsia Indica* (Barachúlí) is found floating on fresh-water tanks; flowering time the cold season; the leaves are round, cordate; the flowers are middle-sized, with a yellow tube and white bearded-limb. *Villarsia cristata* (Chúlí) is also a native of pools of fresh water, where it floats, often not reaching the

Fig. 143.



Villarsia cristata.

bottom with its roots; the flowers are small, white, and appear in the rains and cold season. Chiretta, so much prized in India as a tonic, is the dried plant *Swertia cherayta*, a native of the Himalayas. The large genus *Gentiana* inhabits the mountains of temperate and hot climates. (The Indian *Villarccas* are sometimes now referred to the genus *Limnanthemum*.)

Other genera are: *Swertia* and *Erythraea*, Rich, &c.

Solanaceae

Are herbs, shrubs, or sometimes trees, with alternate exstipulate leaves, and regular, or slightly irregular, flowers; often extra axillary; stamens as many as, and alternate with, the corolla lobes; corolla plaited in aestivation; ovary 2-celled; seeds endospermic; embryo curved.

Fig. 144.



Solanum melongena.

This order, so abundant in the tropics, passes by almost insensible gradations into *Scrophulariaceae*; the latter have, however, an imbricated aestivation of the usually irregular corolla, rarely 5 perfect stamens, and a straight embryo. *Solanum melongena* (Begún), cultivated all over India; is a perennial; leaves obliquely ovate; downy lobed flowers, long peduncled, drooping.

ing, of a violet colour; there are many varieties of this useful species. *Solanum jacquini* (Kanta-káří), a very prickly spreading biennial; leaves frequently in pairs, oblong

pinnatifid, smooth, armed on both sides with long straight prickles; flowers in extra axillary peduncles, of a bluish colour; the fruit, while immature, is variegated green and white; when ripe, of a yellow colour. *Solanum tuberosum*

Fig. 145.

Section of the capsule
of *Datura*.

flowers of a pale blue colour. *Datura alba* (Dutúrá) is

Fig. 146.

*Nicotiana glauca*.

from South America, is also cultivated in the cold season for its fruit. *Petunia nyctaginiflora* is a South American

(Bilati alú), introduced from South America, and now cultivated all over the world; the flowers are of a white or bluish colour. *S. verbascifolium* (Aras), a large shrub with alternate oblong entire leaves and small white numerous flowers, which appear during the hot season. *S. Indicum* (Byákúr), a very ramous armed shrub, with ovate downy leaves coated with prickles; very common everywhere in India; the flowers are very large, white, and appear throughout the year: a strong narcotic is prepared from the seeds and leaves. *D. fastuosa* (Kála dhútúrá) is more poisonous than the white species. *Nicotiana tabacum* (Tamák), introduced from America, and now cultivated in many parts of India; the flowers are large, rose-coloured, and appear in the cold season. *Capsicum frutescens* (Lankhámari) is a shrubby plant, with ovate lanceolate leaves and small white flowers, which appear throughout the year: several other species of *Capsicum* are cultivated. *Physalis peruviana* (Tepáří) is largely cultivated in India for its berries, which are wholly concealed within the accrescent calyx. *Lycopersicon esculentum* (Tomato), introduced

annual, very common in gardens ; in flower the whole year. *Atropa belladonna* (Deadly nightshade), a native of Europe and Western Asia, has the curious property of relaxing the iris, and thus causing dilatation of the pupil. *Hyoscyamus niger* (Henbane), a common plant on waste places throughout Europe and Western Asia, as far west as the Western Himalayas, is cultivated in India for medicinal purposes. This order includes, besides many valuable food plants, many dangerous narcotic poisons. The most important food-producing species are the potato, the tomato, the tepari, and the capsicum, which is remarkable for the pungent quality of its fruits. The poisonous species are tobacco, henbane, and deadly nightshade.

Fig. 147.



Style 3-lobed (enlarged). *Phlox drummondii*.
account of the beauty of its flowers.

Polemoniaceae

Are herbs, with alternate or opposite leaves and regular 5-merous and 5-androus flowers; the lobes of the corolla usually contorted, in aestivation; ovary 3-celled, with three styles; seeds endospermic; embryo straight.

The habit, form of the corolla, and structure of the ovary separate this order from *Convolvulaceae*. *Phlox drummondii*, a delightful annual, with numerous varieties, belongs to this order; it is largely cultivated in gardens in India on

Other genera are: *Polemonium*, L.; *Gilia*, Ruiz and Pav.; *Collomia*, Nutt; *Caldasia*, Wild.

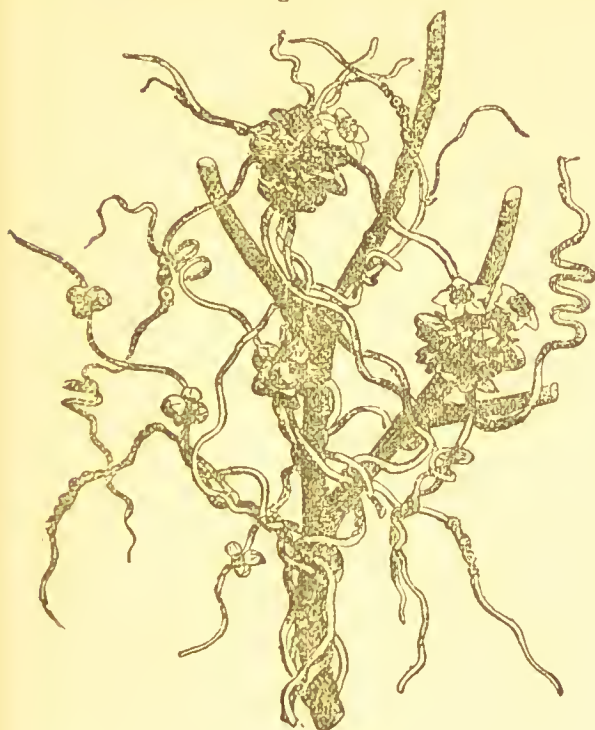
Convolvulaceæ

Are chiefly herbs, twining or trailing, with alternate leaves and regular 5-androus flowers; calyx imbricated; the funnel-shaped corolla induplicate, valvate or plaited in the bud; ovary 2 to 4-celled, with one or two ovules in each cell; embryo large curved. *Cuscuta*, which belongs to this order, is a genus of leafless parasites.

The regular sympetalous *Boraginaceæ* approach this order, but are separated by the curved embryo and the usually 2-celled ovary; the ovary also distinguishes it from *Polemoniaceæ*, which has got a 3-celled ovary. *Argyrea speciosa* (Bich-tarak) is a herbaceous shrub, twining to a great extent; is a native of hedges, &c.; the leaves broad, cordate; flowers large, of a deep rose-colour; flowering time the wet and cold seasons; the fruit is a berry. *Ipomœa bonanox* (Kalmilatá) has large pure white flowers, expanding at sunset; fruit a capsule. *Ipomœa Quamoelit* (Kámalatá), a native of various parts of India; it flowers during the rainy season; leaves pinnate; leaflets filiform: there are two varieties—the scarlet and the white. *Batatas paniculata* (Bhúin-kúmrá) has large rose-coloured flowers, with a dark purple centre; the root is cathartic. *Batatas edulis* (Shakar kanda-alu), sweet potato, cultivated everywhere for its large fleshy tubers. *Ipomœa Nil* (Nil kalmi), common in most parts of India; flowers pale blue; appear in the rains; the fruit is 3-celled; the seeds are sold in the bazars under the name of kaladana, a useful cathartic. *Ipomœa reptans* (Kalmi-shak), an annual creeper, or floating on fresh water; flowers large, pale rose-coloured, with a dark purple centre; the tender tops and leaves are sometimes eaten. *Ipomœa Sepiaria* (Ban-kalmi) is a very common species; the flowers are pale rose colour, with a dark purple centre; it flowers most of the year; the fruit is 2-celled. *Cuscuta reflexa* (Haldi algosa-lata), a parasite on trees and shrubs; branches filiform, twining, smooth, yellow; flowers are small, white, and appear in

February and March. The *Cuscutæ* are remarkable for their

Fig. 148.



Cuscutæ.

leafless and parasitic habit; the embryo is spirally twisted, and is usually destitute of cotyledons; it germinates in the ground, but soon lays hold of some neighbouring plant, on which it becomes parasitic.

A purgative property generally characterizes these plants. *Jalap* is the root of *Exogonium purga*, a Mexican species. *Scammony* is the dried root of *Convolvulus*

scammonia, a native of Asia Minor and Syria; the seeds of *Ipomœa nil* are well-known in every bazar in India under the name Kala-dana, a safe and effectual cathartic.

Boraginaceæ

Fig. 149.



The 4-lobed ovary, with gynobasic style of *Borago*.

Are mostly herbs, with alternate rough leaves, a scorpioid inflorescence and symmetrical flowers; stamens 5, epipetalous; ovary deeply 4-lobed, surrounding the gynobasic style.

The 4-lobed ovary and fruit of this order agree exactly with those of Labiata, from which, however, almost all its other characters distinguish it. *Trichodesma Indicum* (Chota kalpa), common over most parts of India, is

a diffuse annual, with entire stem clasping hairy leaves; the lower ones opposite; flowers pale blue, regular. *Helio-*

Fig. 150.

*Heliotropium Indicum.*

tropium Indicum (Hatsura) is one of the most common plants in India; it is in flower at all seasons, appearing in corners on rubbish, where the soil is rich and dry; the flowers are small of a lilac blue colour.

Cordiaceæ is combined with *Boraginaceæ* by Bentham and Hooker, from which, however, they differ in the drupaceous fruit and plaited cotyledons. *Cordia myxa* and *C. latifolia* are trees common in many parts of India; they yield the large and small Sebestens, which are used in medicine.

Other genera are: *Ehretia*, L.; *Heliotropium*, Tournef; and *Echium*, Tournef. The Forget-me-not is a European species of the genus *Myosotis*.

Labiataæ

Are herbs, rarely shrubs, with square stems, opposite aromatic leaves, and irregular flowers; stamens didynamous, or diandrous; ovary deeply 4-lobed, surrounding the gynobasic style.

The deeply 4-lobed ovary and gynobasic style separate

Fig. 151.



Salvia Officinalis. The corolla cut open, showing the ovary, style, and stigma.

this order from *Verbenaceae*, its nearest ally. *Ocimum basilicum* (Babui tulsi), an erect aromatic herb, with square stems, opposite petioled ovate to ovate serrate, smooth leaves, and bilabiate white flowers in terminal racemes, which appear during the whole year. *Ocimum sanctum* (Tulsi), cultivated in the gardens belonging to Hindoo temples and in masonry vases above every ghat ; in flower all the year round ; the whole plant aromatic, and of a purplish colour ; the leaves are oval, serrate, downy ; and the flowers are small, of a pale purple colour. *O. gratissimum* (Ram tulsi), a very strongly

aromatic plant, with small whitish yellow flowers, which appear during the whole year. *Mentha viridis* is (Pudina), common in gardens throughout India; the flowers are small, purplish. *M. piperita* is supposed to be of garden origin, and to have originated from *M. aquatica*. *Salvia coccinea*, a small herbaceous plant, very common in gardens, blossoms all the year round; flowers arranged in spikes of a scarlet colour; the anther cells are removed from each other by a long connective. *Lavandula vera*, a native of the south of Europe, furnishes lavender, the oil of which is used in medicine. The species of this very large order are most plentiful in the Mediterranean region, where also the more fragrant kinds occur.

Other genera are: *Rosmarinus*, Tournef; *Micromeria*, *Marrubium*, Tournef; *Anisomeles*, R. Br.; *Coleus*, Lour; *Meriandra*, Benth; *Pogostemon*, Desf, &c.

Verbenaceæ

Are herbs, shrubs, or trees, with opposite or alternate leaves and irregular flowers; stamens didynamous; ovary 4-celled; style terminal.

This large order is chiefly tropical; the species are generally trees or shrubs; the terminal style and more coherent carpels separate this order from *Labiatae*. *Clerodendron siphonanthus* (Bamun-hati), shrubby, with lanceolate entire leaves and greenish white flowers, bearing an exceedingly long slender tube; when the flower opens, the four-filaments project in a double curve, afterwards they become revolute; they appear from April to May, and from August to January. *Clerodendron viscosum* (Bhant), a pretty shrub when in flower; it is generally found under the shade of large trees, in consequence of the birds dropping the seeds there; flowers large, white tinged, with rose colour on the inside; they appear in February and March. *Vitex negundo* (Nishindá), a small tree, with opposite ternate or quinate leaves and terminal panicles of small, purplish blue, irregular flowers, which appear in the hot and rainy seasons: a decoction of the aromatic leaves helps to form the warm bath for native women after delivery, and amongst the natives few plants appear to have a greater range of uses. *Tectona grandis*

(Según) is the species of this order of greatest importance in India, affording one of the best and most durable timbers known ; the flowers are small, white, and appear in the rains. *Petrea volubilis*, a climbing shrub common in gardens, has showy panicles of violet flowers. *Duranta plumieri*, also very common in gardens, has spikes of small blue flowers. *Holmskjoldia sanguinea*, a scandent shrub, has scarlet flowers ; the calyx is coloured. *Aloysia citriodora*, a South American plant, is common in gardens.

Other genera are : *Gmelina*, L. ; *Lantana*, *Callicarpa*, L. ; *Premna*, L. ; *Congea*, Roxb. ; *Stachytarpheta*, Vahl. ; *Zapania*, Juss. &c.

Scrophulariaceæ

Are chiefly herbs, with opposite or alternate leaves and irregular flowers ; corolla imbricated ; stamens didynamous or diandrous, springing from the tube of the corolla ; ovary 2-celled ; fruit, a 2-celled, many-seeded, capsule ; endosperm copious.

The imbricated æstivation, the stamens fewer than the lobes of the corolla, and the straight embryo, generally speaking, distinguishes this order from *Solanaceæ*. *Celsia coromandeliana* (Koksin) is an erect ramous annual herb, with lower leaves lyrate, the upper sessile cordate ; flowers small, bright, sulphur coloured, appearing during the cold season. *Lindenbergia urticæfolia* (Haldí basanta) is very common everywhere, and is in flower throughout the year ; it generally grows on old walls ; the flowers are small, yellow. *Antirrhinum majus* (Snapdragon) has a personate corolla ; it is frequently cultivated in gardens. *Maurandya semperflorens* is a climbing garden plant, introduced from America, with alternate leaves and solitary rose-coloured flowers. *Picrorrhiza kurrod*, a plant of Kumaon and other parts of Northern India ; the root is used medicinally. *Monniera*, a small creeping plant, also sometimes used in medicine. Many of the *Scrophulariaceæ* are parasitic upon the roots of other plants ; as for example, *Pedicularis*, of which a large number of species occur in the Himalaya, and *Rhinanthus*.

Other genera are : *Verbascum*, Tournef. ; *Linaria*, Tournef. ;

Stemodia, L.; *Limnophila*, R. Br.; *Peplidium*, Delile; *Bonnaya*, Lk.; *Vandellia*, L.; *Torenia*, L., &c.

Utriculariaceae

Are herbs, growing in water or wet places; flowers with a 2—5-parted calyx, and a 2-lipped personate spurred corolla; stamens 2; ovary 1-celled, with a free central placenta.

The 1-celled ovary, with free central placenta, and the habit distinguish this order from *Scrophulariaceae*. *Utricularia stellaris* (Bara jhángí), a plant floating in fresh water; it appears and flowers during the rains; the submerged leaves with capillary segments bear small bladders; the flowers are small, yellow. *U. reticulata* has blue flowers; *U. nivalis* has very small white flowers; and *U. diantha* is the smallest species, with very small yellow flowers. The structure of the leaves of *Utricularia*, especially that of their air-floats, is very curious. These plants are found in all except the colder parts of the globe, the pouches of *Utricularia* have the property of dissolving and absorbing animal matter, such as insects, &c.

Orobanchaceae

Are fleshy herbs, destitute of green foliage, with usually dull-coloured flowers; stamens didynamous; ovary 1-celled, with 2 to 4 parietal placentas; embryo rudimentary.

This order is remarkable for its parasitical habit, its fleshy texture, its scale-like leaves, and the absence of chlorophyll. *Orobanche Indica* is found in blossom in January, adhering to the roots of tobacco plants; the flowers are arranged in dense spikes, and are of a blue colour. *O. acaulis* grows on the roots of the sugarcane; the flowers are of a beautiful purple, and are in full blossom in September. *Æginctia Indica* is common about Silhet, Deyra-Dhoon, &c.; the flowers are large, purple. Another species, *Æ. pedunculata*, is a common parasite on the roots of *Andropogon muricatus*.

These plants germinate in the ground, and immediately attach themselves to the roots of various plants, on which

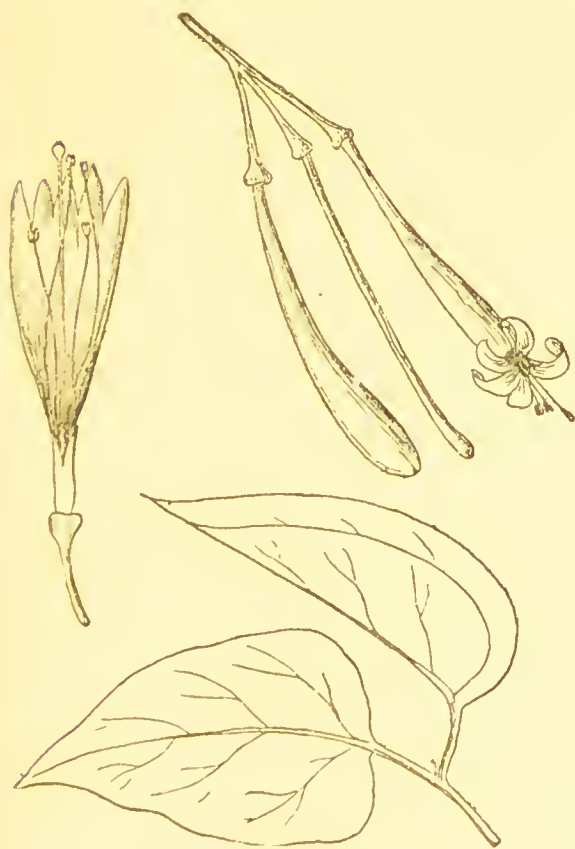
they become organically grafted ; they are widely distributed.

Bignoniaceæ

Are usually woody, rarely herbaceous, plants, often twining or climbing, with exstipulate compound leaves ; flowers irregular ; corolla commonly trumpet-shaped ; stamens didynamous or diandrous ; ovary 2-celled ; seeds numerous, winged, without endosperm.

The winged seeds without endosperm, together with the

Fgi. 152.



Bignonia venusta (reduced).

compound leaves, and general character of the inflorescence, distinguish the plants of this order from their nearest affinities. *Calosanthus Indica* is a large tree, with opposite pinnate leaves and terminal racemes of trumpet-shaped flowers—outside, of a dark purple colour, inside of a yellowish white ; the capsules are very long and flattened. *Bignonia venusta* is a climbing shrub, very common in gardens, blossoming in January and February in such

luxuriance, as to cover the entire surface of the plant with flowers ; Babu P. Ch. Shaha, Curator, Hughli Botanical Garden, has drawn my attention to the fact that the flowers of

this plant are heterostyled. *Crescentia Cujete* (Calabash), cultivated in gardens, belongs to this order. The *Crescentiaceae* are sometimes regarded as a distinct order, differing from the *Bignoniaceae* in their indehiscent fruit and wingless seeds.

Many *Bignoniaceae* are remarkable for the structure of their woody stems, caused by the wood being divided into segments by broad wedge-shaped layers of liber.

Fig. 153.



Sesamum Indicum.

cultivated everywhere over India, with entire or 3-lobed

of their woody stems, caused by the wood being divided into segments by broad wedge-shaped layers of liber. The wings of the seeds are seen to be very beautiful when examined under the microscope.

Other genera are: *Spathodea*, Beauv; *Tecoma*, Juss.; *Schrebera*, Roxb., &c.

Pedaliaceae

Are herbs, with opposite leaves and irregular flowers; stamens fewer than the corolla lobes; seeds generally wingless.

This order is distinguished from *Bignoniaceae* by its habit, indurated pericarp, and wingless seeds. *Sesamum Indicum* (Til), an annual pubescent herb,

leaves and axillary slightly bilabiate white rose-coloured flowers; the seeds contain an oil resembling olive oil. *Pedaliium murex* is a common plant in many parts of the Madras Peninsula, especially near the sea; an infusion of the leaves and stems is used for medicinal purposes. *Martynia diandra*, a Mexican plant, domesticated in India, is remarkable for its curious 2-horned fruit.

Acanthaceae

Are herbs or shrubs, with opposite, simple, exstipulate leaves; flowers irregular, bracteated; stamens didynamous or dian-drous; ovary 2-celled, with two or more ovules in each cell; fruit a 2-celled capsule with indurated placentas.

The large bracts of the inflorescence and the imbricated calyx of unequal sepals give a characteristic appearance to these plants. By Bentham and Hooker the order is divided into five tribes, viz., *Thunbergiaceae*, *Justicieae*, *Acantheae*, *Ruellieae*, and *Nelsonieae*; the distinctions are founded upon the nature of the calyx, the aestivation of the corolla, the characters afforded by the seeds, &c. *Thunbergia grandiflora* (Níl-lata) is a climbing woody perennial, with very large blue and white flowers, which are produced the whole year. *Justicia adhatoda* (Bakas) is a small tree common over most parts of India; flowering time the cold season; the leaves are opposite, entire; the flowers are large, white, spotted with small ferruginous dots, the lower part of both lips is streaked with purple; this plant is used by the natives in the cure of coughs, asthma, ague, &c. *Justicia paniculata* (Mahá-titá) is a native of dry ground, under the shade of trees, &c.; flowering time the wet and cold season; flowers rose coloured; the plant is used as a tonic, analogous to Quassia in its action. *J. tinctoria* (Bet-rang), a herb common in Bengal, with opposite, oblong, entire, downy leaves, and rose-coloured flowers, which appear during the rains and cold season. *Acanthus ilicifolia* (Hakúch kanta), a common shrub; it flowers during the rains; the flowers are solitary, opposite, large, blue, inodorous. *Ruellia longifolia* (Kántá kulika) is a plant common in low wet places all over India, flowering time the cold

season; the flowers are bright blue; some varieties are rose-coloured: the plant is considered tonic and diuretic. *Nel-sonia tomentosa* (Para mûl), a sub-erect hairy herb, a native of wet pasture ground; flowering time the wet and cold season; the flowers are small, bright, bluish purple.

This is a very large order, but the plants are mostly without active properties. *Andrographis paniculata*, common in shady places all over India; is sometimes used as a bitter tonic, analogous to Quassia in its action. *Hygrophila spinosa*, common in moist places in most parts of India; has valuable diuretic properties assigned to it. *Justicia gendarussa* and *Rhinacanthus communis* are also sometimes used in medicine. *Acanthus mollis* is interesting from its leaves having, it is said, furnished the model of the Corinthian capital.

Loranthaceæ

Are parasitic shrubs, with opposite or alternate exstipulate leaves; flowers perfect or diclinous; stamens 4 to 8, superposed to the segments of the coloured perianth; ovary inferior.

These plants are distinguished by their peculiar habit, being stem parasites.

Fig. 154.



Parasitic roots of *Loranthus* growing on a branch of *Morus alba* (tût.)

Loranthus bicolor (Bara-manda) is always found growing on the branches of various kinds of trees, and is very ramous; it flowers during the greater part of the year; the flowers are of a greenish orange scarlet colour; the leaves are oblong, smooth.

L. globosus (Chota-manda), a common

ramous shrubby parasite on trees; it flowers the whole year; the berry is round, about the size of a pea; the

flowers are greenish orange. Several species of *Viscum* (Mistletoe), both with and without leaves, are common parasites in India; they differ from the species of *Loranthus* in their unisexual flowers and adnate anthers dehiscing by pores. The germination of the seeds exhibits some interesting phenomena; they adhere to the young shoots of trees by means of the viscid pulp of the fruit, where they germinate and push their roots through the bark to the cambium layer, with which they contract an organic adhesion. In *Loranthus* the ovule is not distinguishable from the ovary until after fertilization.

Santalaceæ

Are herbs, shrubs, or trees, with entire leaves; stamens superposed to the lobes of the perianth; ovary 1-celled, with 2 to 4 ovules, suspended from a free central placenta.

The pendulous ovules, with the embryo developed entirely outside the nucleus in the protruded part of the embryo sac, is a very remarkable and striking character of this order. *Santalum album* (Chandun) is a tree with fragrant wood and opposite oblong entire smooth leaves; flowers numerous, small; at first of a straw colour, afterwards changing to a rusty purple; the wood is used for various purposes, boxes, &c., being made of it; it is burnt as incense in temples and dwellinghouses both in India and China, and when reduced to powder it enters into a composition for marking the forehead.

Aristolochiaceæ

Are climbing shrubs or low herbs, with an irregular or regular perianth valvate in the bud; stamens 6 to 12, more or less adherent to the style; ovary inferior, from 3 to 6-celled.

The ternary structure of the flower, the curiously shaped perianth, the stamens adherent to the style, and the peculiar structure of the wood, which presents no concentric rings, distinguishes this order from all others. *Aristolochia Indica* (Ishwar-mûl) is a smooth twining shrub, with alternate leaves and axillary very irregular; brownish red green flowers, which appear in the rains; it is a native of jungles, where the soil

is dry and poor ; the root is sometimes used as a tonic, &c. *A. caudata*, cultivated in gardens, has large helmet-shaped flowers. *A. bracteata*, a common plant throughout India ; it is well known by its Hindustani name kirá-mát from its supposed anthelmintic properties. *Brugantia Wallichii* is a small shrub, a native of the Malabar Coast, where it is known by the name of Alpaus ; it is used in medicine.

Piperaceæ

Are herbs or shrubs, with jointed stems and alternate or opposite simple leaves ; flowers achlamydeous, unisexual, or hermaphrodite, in spikes or racemes ; ovary 1-celled, with a single erect ovule, with the embryo in a distinct sac, surrounded by the endosperm, in a hollow of the copious perisperm.

The stems of Piperaceæ are very peculiar ; there is a kind of double concentric circle of fibro-vascular bundles, the inner circle supplying the leaves, but not possessed of a cambium region, while the outer circle is of the ordinary open character ; they are connected with the monocotyledonous type through *Aroideæ*. *Chavica betle* (Pán), much cultivated in India by slips and cuttings grown in a rich moist soil well enclosed and shaded, so that they are in a great measure protected from both sun and wind ; the jointed stems are woody, climbing, or creeping, giving off numerous adventitious roots ; leaves alternate, cordate, somewhat pointed, entire, smooth, from 4 to 6 inches long, and from 2 to 4 broad ; flowers minute dioecious, arranged in catkins, appearing during the rains and cold season. *Chavica Roxburghii* (pipúl), a creeping shrubby dioecious plant ; it flowers during the wet and cold seasons ; long pepper consists of the dried flower spikes of this plant. *Piper nigrum* (Gol-marich), the unripe dried berries are black pepper ; white pepper is the same fruit with the fleshy epicarp removed by washing. The dried unripe fruit of *Cubeba officinalis*, a native of Java and the Moluccas, is used in medicine as a stimulant. The leaves of *Artanthe elongata* are esteemed as a styptic, known in South America by the name of Matico.

Euphorbiaceæ

Are herbs, shrubs, and trees, mostly with milky juice and usually alternate stipulate leaves and monœcious or diœcious flowers. The flowers are achlamydeous (*Euphorbia*, *Poinsettia*), monochlamydeous (*Phyllanthus*, *Acalypha*, *Ricinus*), or dichlamydeous (*Croton*, *Jatropha*); ovary free, usually 3-celled, usually separating when ripe into as many cocci, which separate when ripe, with one or two pendulous ovules in each cell.

The unisexual flowers and the compound ovary, generally consisting of 3 carpels, is usually sufficient to distinguish this order from its nearest allies. *Ricinus communis* (Bherandá); of this useful plant there are several varieties cultivated in India; the leaves are peltate, palmately lobed serrate; the flowers monœcious, in terminal panicles; fruit prickly. *Xylophylla angustifolia*, cultivated in gardens, has peculiar flattened stems, cladodes. *Croton tiglium* (Jypal) grows to be a small tree; flowers small, greenish yellow; it produces the famous croton oil. *Rottlera tinctoria* (Púnnág) is a tree with alternate, ovate, oblong leaves; the red mealy powder, which covers the capsule, is used as a dye. *Jatropha multifida* (Coral plant) is a succulent plant, commonly cultivated in gardens; the flowers small, red, arranged in cymes, borne upon erect succulent peduncles. *J. curcas* (Bághberándá) domesticated from South America; flowers small, green, and appear throughout the year; the seeds are purgative and emetic; the oil expressed from them is used as an external application in itch and other skin diseases; a varnish is made from the oil by boiling it with oxide of iron. *Tragia involucrata* (bichhatí), a twining shrubby plant, a native of shady places, where the soil is good; the leaves are oblong, serrate, the hairs of the plant sting like those of the common nettle; the flowers are small, greenish, and appear throughout the year. *Acalypha Indica* (Mukta júrí), a very common annual; in flower all the year round; leaves ovate, cordate, 5 nerved, serrate, smooth, about two inches long and one-half broad; flowers small, greenish; the bruised root is used as a cathartic; a decoction of the leaves is used as a laxative. *Euphorbia antiquorum* (tekátá-sij) is a shrubby leafless succulent plant, with spreading triangular branches, armed

with double spines, very common on barren uncultivated lands all over India. *Euphorbia chamasyce* (Chotá keraí)

Fig. 155..

*Pedilanthus tithymaloïdes* (reduced).

hedges, as goats and cows, &c., seldom eat the leaves: the flowers are protogynous. *Poinsettia pulcherrima* (Lalpátá); the flowers are small, of a greenish yellow colour; the bracts are large, and are of a bright vermilion.

Casuarinaceæ

Are pseudo leafless trees, with pendulous jointed striated branches; male flowers in catkins; female flowers in strobiles, stamen 1; ovary 1-celled, with 2 to 4 ascending ovules. Fruit, a group of foliicles, collected into cones.

The *Casuarinaceæ* connect the angiosperms to the gymnosperms through the *Gnetaceæ*; they are trees of remarkable aspect, the branches having much the appearance of the branched *Equiseta*; they acquire large dimensions, the wood of the trunks becoming solid and heavy; the greater portion of them are natives of Australia. *Casuarina equise-*

and *E. hirta* (Bara keraí) are also very common everywhere. *E. Tirucalli* (Lankáshij), a native of various parts of India; the flowers are small, yellowish, and appear in the rains; the milky juice is used for blistering. *Pedilanthus tithymaloïdes* (Ráñgehitrá) was introduced into this country from South America in 1794, and is now domesticated everywhere; it is used chiefly for

tifolia (Jhau), a conspicuous object in every station in India ; is a very tall, handsome tree, with pendulous jointed striated branches ; it flowers during the hot season. *C. muricata*, an Arracan and Malayan tree, much cultivated in India ; its bark is used as an astringent ; the wood is usually of a reddish colour.

Urticaceæ

Are herbs, shrubs, or trees, with alternate stipulate leaves and small unisexual flowers ; perianth green, free from the 1-celled ovary ; stamens equal in number, and opposite to the perianth lobes, uneoiling elastically ; ovule one ; embryo straight in the endosperm when this is present.

The 1-celled ovary, the endospermic seeds, and the flowers not arranged in catkins, distinguishes this order from its nearest allies. *Bœhmeria interrupta* (Lal bichhatî), an erect annual ; leaves cordate, serrate ; flowers small, pale greenish yellow ; flowering time the rainy season ; the hairs of this plant sting like those of the common English nettle. *Bœhmeria nivea*, an erect shrub, with alternate cordate leaves and small diœcious greenish yellow flowers in axillary globose heads ; this plant furnishes the fibre for Chinese "grass cloth" Rhea.

Artocarpacææ

Are trees or shrubs, rarely herbs, with milky juice and alternate stipulate leaves and dielinous flowers ; female flowers in heads, or on flat receptacles ; stamens non-elastie ; ovary 1-celled ; embryo straight, or eurved ; endosperm fleshy, or none.

Artocarpacææ is sometimes regarded as a sub-order of Urticacææ, the main difference being in the habit, the milky juice, and the pendulous ovules of Artocarpacææ. The enfloroseence and fruit of these plants is very curious. *Ficus Indica* (Banyan tree) is one of the best known trees in Bengal, and is remarkable for sending down numerous roots from the branches, which strike into the earth, and convert the tree into a kind of grove ; the flowers are enclosed in an excavated fleshy peduncle ; they appear

during the hot season; the leaves, when joined together, are frequently used as a substitute for plates. *F. Religiosa* (Ashwath, Pippal), a

Fig. 156.

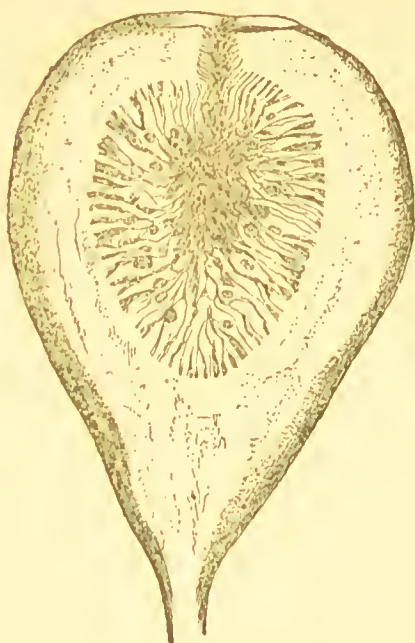
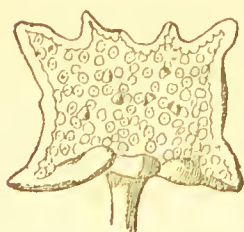
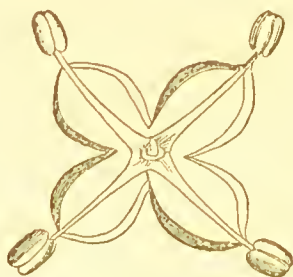
Section of the receptacle of *Ficus*.

Fig. 157.

very large tree common in every part of India; birds are very fond of the fruit, which they eat greedily, and often drop the seeds in cracks of buildings, in the axils of the leaves of the date-tree, etc., where they vegetate; the wood is white, light, and of little use. *F. Carica* (Dúmúr) is cultivated for its fruit. Caoutchoue is obtained from *Ficus elastica*, etc. *Dorstenia contrajerva* is easily cultivated; the minute flowers of which are embedded in the top of a tabular fleshy peduncle. *Artocarpus integrifolius* (Kántál) is much culti-

Fig. 158.

Fig. 159.

Expanded receptacle of *Dorstenia contrajerva*.Male flower of *Morus*.Female flower of *Morus*.

vated everywhere for the sake of its fruit; the numerous flowers are crowded on a globular fleshy peduncle, which enlarges into a large fleshy fruit; they always grow from the trunk and large branches. *A. Lakoocha* (Dephal) common all over Bengal; the leaves fall off during the cold season; the fruit is sometimes eaten. *Morus alba* (Tút)

is cultivated in gardens, the flowers are small, greenish, and appear at the end of the cold season.

Cannabinaceæ.

This order is closely allied to *Urticaceæ*, but differs in the non-elastic stamens and the curved embryo.

This order is sometimes regarded as a sub-order of *Urticaceæ*, but differs in the stamens not being elastic and in the curved aperispermic embryo. *Cannabis sativa* is a

Fig. 160.



Palmatisect leaf of *Cannabis sativa*, Ganjá.

diœcious herb with palmatisect leaves and small greenish white flowers, cultivated near villages for its narcotic, resinous leaves and flowers (males in loose panicles, females sessile),

which are smoked as "bhang," "subja," or "sidhé;" this plant is also known for the tenacity of its fibre. Gunjá is the dried flowering plant from which the resin has not been removed. Chirus is the resinous exudation from the leaves, stem, and flowers. Majun is a compound of bhang, sugar, flour, and milk.

Elæagnaceæ

Are small trees or shrubs, with scaly leaves; flowers herma-

phrodite in *Elæagnus* itself (and this includes 12 of the 15 species), diœcious or polygamous in the other species; perianth tubular, contracted beyond the ovary; stamens as many as the lobes of the perianth, and alternately with them or twice the number; pollen-grains triangular or ovoid; ovary 1-celled; seed ascending.

Fig. 161.

*Elæagnus conferta.*

This order is separated from *Thymelæaceæ* by the valvate perianth and the erect ovule. *Elæagnus conferta* is a shrub with alternate entire leaves, the underside of which is covered with minute peltate scale-like hairs, which are beautiful objects under the microscope; the flowers are small, yellowish, and appear during the cold season. The fruits of several species of *Elæagnus* are eaten in Persia and India.

Proteaceæ

Are trees or shrubs, with hard, dry, exstipulate leaves; perianth 4-cleft valvate; stamens 4, superposed to the segments of the perianth; anthers dehiscing longitudinally; pollen-grains usually triangular; ovary 1-celled, free, with 1 or 2, rarely several, ovules. Fruit usually woody, dehiscent.

The rigid foliage of these plants is peculiar. *Grevillea robusta*, a tree introduced from Australia, now extensively grown along the borders of roads; the structure of the stomata are peculiar. *Helicia* is the only genus represented in the indigenous flora of India; it extends to China and North Australia.

Fossil proteads are believed to be amongst the first dicoty-

ledones, of which traces remain in geological formations; at present these plants are chiefly found in Australia and in South Africa.

Other genera are: *Protea*, L.; *Bauksia*, L., Fill., &c.

Lauraceæ

Are aromatic trees or shrubs, with alternate or opposite simple exstipulate leaves; perianth imbricated; stamens definite; anthers opening by valves; seeds solitary, pendulous, without endosperm.

The peculiar opercular dehiscence of the anthers distinguish this order from its nearest allies. *Cinnamomum zeylanicum* (Dálchini) is a small tree, with opposite, entire, smooth, 3-nerved leaves, and terminal and axillary panicles of small greenish white flowers. *Cinnamomum camphora* is a tree, from the wood, branches, and leaves of which camphor is produced by distillation. *Tetranthera Roxburghii* (Kúkur chitá) is a middle-sized tree, with oval to lanceolate leaves, and dioecious flowers, which appear at the beginning of the rains. *Cassyta filiformis* (Akash balli) is a twining leafless parasitic plant, bearing true Lauraceous small white flowers; it bears the same relation to the rest of the order that *Cuscuta* bears to *Convolvulaceæ*. The most marked properties of these plants depend on the presence of aromatic oils and camphor. Warburg's tincture includes a preparation from the bark of *Neetandra Rodiæi* of Guiana. *Laurus nobilis*, the classic or true Laurel, is a native of the south of Europe.

Other genera are: *Sassafras*, Nees; *Neetandra*, Rottle; *Litsæa*; *Ocotea*, Aubl.; *Persea*, Gärtn.; *Laurus*, Tournef., &c.

Myristicaceæ

Are aromatic trees, with alternate, entire, leathery, exstipulate, dotted leaves; flowers diclinous; stamens monadelphous; fruit succulent, 1-celled, 1-seeded; seed erect, surrounded by an arillas; endosperm ruminated.

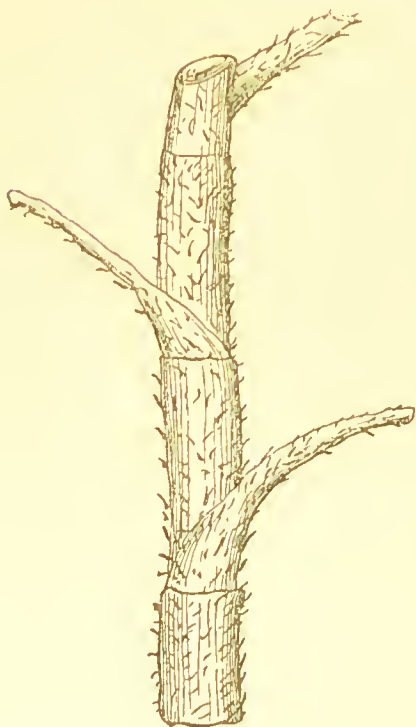
The nearest relations of this order are perhaps the

thalamifloral orders, Anonaceæ and Magnoliaceæ, but the declinous apetalous condition of the flowers of Myristicaceæ distinguish them from the plants of those orders. *Myristica moschata*, a tree with alternate entire leaves, and small pale yellow inodorous flowers, which appear in the rainy season; nutmeg (Jayphal) is the seed with ruminated endosperm; mace (Jaitri) the arillas surrounding the seed. In their active qualities and habit, these plants somewhat resemble those of Lauraceæ.

Polygonaceæ

Are herbs or shrubs, with alternate simple leaves and usually ochraceous stipules, above the swollen joints of the stem; flowers very small; ovary 1-celled, with 3 or 2 stigmas; ovules solitary, erect, orthotropous; fruit a triangular nut; seeds endospermic.

Fig. 162.



Ochraceous stipules of *Polygonum pilosum*.

The ochraceous stipules and the solitary erect seeds, with their embryos having the radicle turned upwards, separates this order from *Chenopodiaceæ*, *Amarantaceæ*, and *Nyctaginaceæ*, its nearest allies. *Polygonum pilosum* (Bara páni-marich) is an erect hairy annual common on the borders of such places as are inundated during the rains; leaves long, petioled, ovate, cordate, downy; flowers small, white; flowering time the rainy season. Several other species of *Polygonum* are common; *P. lanigerum* (shwet páni marich); *P. flaccidum* (páni marich), &c.

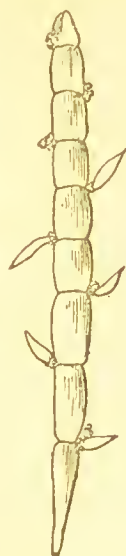
Ramex acutus (Ban pálang); this plant is common in

Fig. 163.



Fruit of *Ramex*.

Fig. 164.



Flattened
stem of
Cocoloba
platyclada.

low situations during the dry season; it dies away in the rains; the flowers are yellowish white, and appear in January, February, and March. *Ramex visicarius* (Chúk palang) is sometimes used as a vegetable. The stems of *Cocoloba platyclada* are flattened, resembling leaves (cladodes). This order is especially abundant in temperate climates; the foliage of these plants is frequently characterized by the presence of oxalic and malic acids. The roots are more or less powerfully purgative. *Rhubarb* is the root of various species of *Rheum*. A climbing *Polygonum* (*P. fagopyrum*) is grown in the Himalayas for its farinaceous seeds.

Amarantaceae

Are herbs or shrubs, with opposite or alternate exstipulate leaves, and a bractiated inflorescence, perianth scarious, or colored; ovary 1-celled, 1-seeded, with a curved embryo; seeds with a farinaceous endosperm.

The crowded bractiated inflorescence and the membranous perianth separate this order from *Chenopodiaceae*, its nearest ally. *Digera muricata* (Latá mahúri), an annual common in most cultivated land; the leaves are alternate, ovate, oblong, spikes axillary, twice as long as the leaves; flowers solitary, alternate, small, red; the leaves and tender tops are sometimes eaten. *Deeringia Indica* (Ghol-mahani) is a scandent perennial; leaves alternate, cordate, spikes terminal panicle; it differs from the other plants of this order in its scandent habit and small red baccate fruit. *Amaranthus polygamus* (Champa-nati) grows in almost every soil and situation; the stem is about a foot high,

branching near the base; the flowers are minute and of a greenish color. *A. lividus* (Gobará-nati) is an erect smooth annual, from 2 to 3 feet high; the stem is of a bright red colour, as are also the petioles; the leaves are of a dull greenish purple, with brighter coloured veins; the flowers are small, of a greenish colour. *A. gangeticus* (Lál shák), an erect annual, with sub-erect branches issuing about the middle of the stem; flowers small, of a greenish red colour, arranged in axillary or terminal spikes; a very large number of varieties of this species are cultivated in Bengal, differing chiefly in colour, from green, with the slightest tinge of red, to bright red; one variety has particularly broad leaves, with the margins green, and the centre dark purple. *A. spinosus* (Kántá-nati), an erect ramous annual with sharp spines in the axils of the leaves. *Celosia argentea* (Swet murgá), an erect annual with lanceolate oblong leaves and sub-cylindrical spikes; the flowers are small, white; this plant is found on rice-fields, &c. *Celosia cristata* (Lál murgá), a common erect garden annual, with alternate simple leaves and terminal panicles of flowers, having their peduncles fused together; flowers red or gold coloured. *Gomphrena globosa* (Gul makmal) is an annual at first erect, by age diffuse; heads solitary; there are two varieties, one with crimson flowers, the other with white; they blossom during the rains and cold season. *Achyranthes aspera* (Apang), very common everywhere during the rains; leaves opposite, obovate, downy; flowers greenish.

Chenopodiaceæ

Are chiefly herbs more or less succulent; with usually alternate exstipulate leaves, and minute flowers with a herbaceous perianth; ovary 1-celled, 1-seeded, with a coiled embryo.

The habit and the inflorescence not being bractiated distinguishes this order from Amarantaceæ. *Basella cordifolia* (Púin shák), a common twining succulent perennial, with cordate, smooth, entire leaves; and spikes of small rose-coloured flowers, which appear in January, February, and March; this plant is much cultivated as a vegetable;

there are several varieties of it. *Beta vulgaris* (Palang shák) is also largely cultivated for its root and leaves. *Chenopodium album* (Chandan betú), an erect annual, with alternate leaves and panicles of minute, clustered, greenish flowers. *Spinacia tetandra* (Pinish), an annual erect herb, with alternate lobed leaves, and very small green flowers; much cultivated in Bengal as a vegetable. *Atriplex hortensis* is used as a vegetable; the flowers are polygamous, unisexual, and perfect in the same plant.

This order is most abundantly diffused in waste places outside the tropics.

Nyctaginaceæ

Are herbs, shrubs, or trees, with mostly opposite entire leaves; stem swollen at the joints; perianth petaloid, long, lower part persistent; ovary superior, 1-celled, 1-seeded; stamens, one or several, hypogynous; fruit 1-seeded, enclosed in the hardened base of the perianth; radicle inferior; endosperm mealy.

The peculiar fruit enclosed in the indurated base of the perianth and the inferior

Fig. 165.



Mirabilis Jalapa (reduced).

radicle separtate this order from *Polygonaceæ*. *Mirabilis Jalapa* (Kishno-keli) domesticated in gardens everywhere; is in flower the whole year; there are several varieties of it—the crimson, the yellow, and the white, and a blending of these colors; the perianth is contracted immediately above the ovary; the upper portion separates after flowering; the lower portion is persistent and forms an outer envelope of the fruit; the root acts as a purgative. *Boerhaavia diffusa* (Gadapurna) is a common perennial procumbent plant, with opposite ovate or cordate leaves

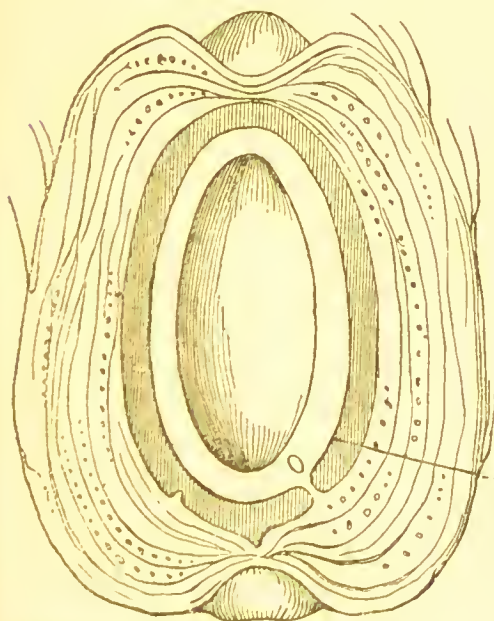
and loose panicles of small red or white flowers. *Pisonia aculeata* (Baghyá chará), a common large straggling shrub, with oblong leaves and greenish white flowers, arranged in axillary panicles; it makes impenetrable hedges. *Bougainvillea spectabilis* and *B. glabra*, domesticated from South America, are remarkable for their bright-coloured bracts. The roots of the Nyctaginaceæ are generally purgative.

MONOCOTYLEDONS.

Flowering plants are classified (see page 80*g*) into two divisions: 1st, Angiospermia, in which the ovules are produced in the interior of a structure (the ovary) formed by the cohesion of carpellary leaves; 2nd, Gymnospermia, in which the ovules are not enclosed in an ovary. The Angiospermia are again divided into two classes—Dicotyledons and Monocotyledons.

The seeds of *monocotyledons* usually contain a strongly developed endosperm and a comparatively small embryo; these are particularly well seen in large seeds, such as those of *Phoenix*, *Crinum*, and *Cocos* (see Fig. 166). In the *Orchideæ* and some other orders, the parts of the embryo of the ripe seed are not differentiated.

Fig. 166.



Section of a coconut showing the seed *x*, with a minute embryo.

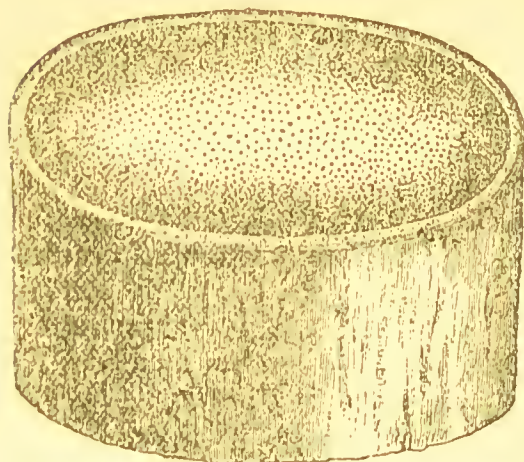
The growth of the primary roots of *monocotyledons* soon ceases, even when they are strongly developed during germination, as in *Palmeæ*, *Liliacææ*, &c.; and secondary roots are developed in their place, which are stronger the higher up they are produced on the axis. In grasses the vascular bundles form a closed hollow cylinder, which at first encloses the central pith.

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secondary roots are developed in their place, which are stronger the higher up they are produced on the axis. In grasses the vascular bundles form a closed hollow cylinder, which at first encloses the central pith.

The plumule of the embryo is usually enclosed in a single sheathing cotyledon, the apex of which usually remains within the seed during germination, and rarely develops into a sheath-like leaf. The axis of the embryo at first takes the form of an inverted cone, dependent on the first formed portions of the stem retaining their original size, while each successive portion is larger; after a time the stem

Fig. 167.



Section of a stem of a palm, showing the isolation of the fibro-vascular bundles.

becomes cylindrical. The most striking peculiarity of a cross-section of a *monocotyledonous* stem at first sight is the isolation of the fibro-vascular bundles (see Fig. 167). The fibro-vascular bundles grow outwards crossing the growing cellular tissue (secondary meristem), in which place they branch,—one division, expanding into a number of fibres, enters the leaf through the epidermal layer, the other taking a similar course to the next older bundle. The bundles being of the closed kind, *i.e.*, being incapable of producing new tissue, they acquire their full development before the leaf to which they belong falls; hence, as a general rule, the stems do not increase in diameter to such an extent as they do in dicotyledons.

The bundles formed from the united fibres are most strongly developed at the curved portion towards the centre of the stem; the lower portion of the bundles being expanded into distinct fibres in a manner similar to the upper portion.

The usual *mode of branching of monocotyledons* is monopodial (see modes of branching, page 15), *i.e.*, the generating structure continues to grow at its apex, while lateral structures are given off beneath it; a bud is generally formed in the axil of each leaf, but often does not unfold, so that the number of branches is often less than that of the leaves.

The *foliage leaves of monocotyledons* are commonly arranged alternately in two rows (see Fig. 168); the arrange-

Fig. 168.

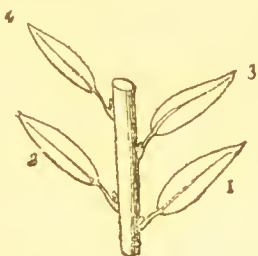
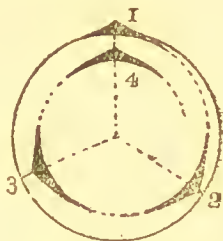


Diagram showing the alternate arrangement of the foliage leaves on the stem, as occurs in many Monocotyledons.

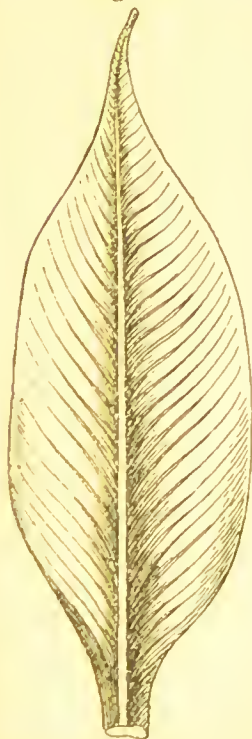
Fig. 169.



Horizontal projection of a cycle of the $\frac{1}{3}$ arrangement of leaves.

ment with the angle of divergence, $\frac{1}{3}$ rd, is much rarer (see Fig. 169), but occurs in some Cyperaceæ, Pandaneiceæ, &c.; in some Musaceæ the angle of

Fig. 170.



Penninerved leaf of *Canna Indica*.

divergence is $\frac{2}{7}$ th: spiral arrangements of foliage leaves are common in Aloe, Palms, &c., &c. The foliage leaves are usually sheathing at the base; this is evidently connected with the want of stipules, which are so frequently found among dicotyledons. The *venation of the foliage leaves* differs from that of most dicotyledons in the veins not generally projecting on the underside of the leaf, but running through the central tissue (or mesophyll); their course, too, is usually parallel, straight, or curved, or when a strong midrib occurs in a broad lamina, as in Musaceæ, &c. (see Fig. 170), the fibrovascular bundles which go through it give off laterally smaller bundles, which run parallel to one another to the margin of the leaf. It is only rarely that the leaves are netveined, as in Smilacaceæ and Dioscoreaceæ.

The flowers of most monocotyledons consist of five alternating whorls (see Fig. 171), each with an equal number of members, *viz.*, an outer and inner perianth whorl, an outer and inner whorl of stamens, and a carpellary whorl. There are usually three members in each whorl.

Fig. 171.



Floral diagram of a typical monocotyledon, as occurs in *Liliaceæ*; representing a flower consisting of five alternating whorls, each with three members, of which the two outer ones constitute the perianth, the two next the andrœcium, and the middle one the gynoecium.

The two whorls of members of the perianth are commonly similar in form and colour; hence they are not usually distinguishable as calyx and corolla; sometimes, however, the outer perianth whorl is green and sepaloid, and the inner whorl larger and petaloid, as in *Alisma*, *Tradescantia*, &c. The stamens of monocotyledons scarcely ever branch as is often the case in dicotyledons.

Adhesion of the perianth and stamens occurs much less constantly in particular families among monocotyledons than among dicotyledons. The prevailing form of the

Fig. 172.



Orthotropic
ovule as in
Smilacaceæ.

Fig. 173.



Campylotropous
ovule as in some
Scitamineæ.

Fig. 174.



Anatropous
ovule as in *Gramineæ*.

ovule is anatropous, as in *Gramineæ* (see Fig. 174); in some *Scitamineæ*, &c., the ovules are campylotropous (see Fig. 173); in *Smilacaceæ* and a few *Aroideæ*, &c., the ovules are orthotropic (see Fig. 172).

ABSTRACT OF MONOCOTYLEDONOUS ORDERS.

The arrangements of monocotyledons lately made by Mr. Bentham is here adopted. He divides the whole class into four series. The two first series, Epigynæ and Coronariæ, include flowers with a double, usually petaloid, perianth, and with a syncarpous ovary. The position of the ovary serves to distinguish the two series; in the 1st, Epigynæ, it is inferior; in the 2nd, Coronariæ, it is superior. The ovary in the 3rd series, Nudifloræ, is mostly apocarpous; and the ovary of the 4th, Glumales, is always uniovular.

MONOCOTYLEDONS.	{	Epigynæ	...	{	Hydrocharideæ : Ex., Vallisneria.
				{	Scitamineæ : Ex., Plantain.
				{	Orchideæ : Ex., Orchids.
				{	Burmanniaceæ : Ex., Burmannia.
				{	Irideæ : Ex., Gladiolus.
				{	Amaryllidaceæ : Ex., Crinum.
				{	Taccaceæ : Ex., Tacca.
				{	Dioscoreæ : Ex., Yam.
		Coronariæ	...	{	Bromeliaceæ : Ex., Pineapple.
				{	Roxburghiaceæ : Ex.
				{	Liliaceæ : Ex., Onion.
				{	Smilacæ : Ex., Smilax.
				{	Pontederaceæ : Ex., Pontedera.
				{	Commelinaceæ : Ex., Tradescantia.
				{	Xyrideæ : Ex., Xyris.
				{	Juncaceæ : Ex., Rush.
Nudifloræ	...	{	Palmeæ : Ex., Palms.		
		{	Pandanaceæ : Ex., Screwpine.		
		{	Aroideæ : Ex., Caladium.		
		{	Typhaceæ : Ex., Elephant grass.		
		{	Pistiaceæ : Ex., Duck-weed.		
		{	Naidaceæ : Ex., Potamogeton.		
		{	Alismaceæ : Ex., Sagittaria.		
		Glumales	...	{	Eriocauloneæ : Ex., Eriocaulon.
{	Cyperaceæ : Ex., Sedges.				
{	Gramineæ : Ex., Grasses.				

SERIES I.—*Epigynæ*.

Flowers with a double, usually petaloid, perianth; ovary usually inferior, syncarpous.

Order I, Hydrocharideæ.—Are aquatic herbs, with usually unisexual regular flowers issuing from a spathe at the end of the scape-like peduncles. Example: *Hydrilla verticellata*.

Order II, Scitamineæ.—Are herbs with irregular bright coloured flowers ; stamen 1 (in the Suborder Muscæ there are 5 fertile stamens). Example : Plantain, Ginger, Arrow-root.

Order III, Orchidææ.—Are herbs with irregular flowers ; stamen usually 1, rarely 2 gynandrous, pollen cohering into waxlike or mealy masses (pollinia). Example : Vanda.

Order IV, Burmanniaceæ.—Are herbs with grass-like or scale-like leaves ; flowers regular, hermaphrodite ; perianth bright coloured ; stamens, 3 introrse, or 6 extrorse. Example : *Burmattia disticha*.

Order V, Iridææ.—Are herbs, with a 6-parted petaloid perianth ; stamens 3 ; anthers extrorse ; stigmas 3, often petaloid. Example : *Pardanehus chinensis* (Das-báhn).

Order VI, Amaryllidaceæ.—Are herbs, with a 6-leaved petaloid perianth ; stamens 6, inserted on the perianth-tube ; anthers introrse. Example : *Crimum Asiaticum* (Barakánár).

Order VII, Taccaceæ.—Are perennial herbaceous plants, with radicle leaves and regular hermaphrodite flowers in umbels or long scapes ; perianth petaloid ; stamens 6, with petaloid filaments ; ovary 1-celled, with 3 parietal placentas. Example : *Tacea primatifida*.

Order VIII, Dioscoreæ.—Plants with twining stems and net-veined leaves ; flowers regular, dioecious. Example : *Dioscorea globosa* (Chupri-álú).

Order IX, Bromeliaceæ.—Are herbs, with fleshy or dry crowded leaves sheathing at the base ; perianth in two circles differently coloured ; stamens 6 ; ovary sometimes superior, 3-celled. Example : *Bromelia ananas*, L.

SERIES II.—*Coronariææ.*

These plants have flowers with a double, usually petaloid, perianth ; ovary superior, almost always syncarpous.

Order I, Roxburghiaceæ.—Are twining shrubs with 4-merous flowers ; ovary 1-celled ; stigma sessile. Example : *Roxburghia*.

Order II, Liliaceæ. — Are herbs, with parallel-veined leaves and regular 6-androus flowers ; anthers introrse ; ovules anatropous or amphitropous. Example : *Allium cepa* (Onion).

Order III, Smilacææ.—Are herbs or climbing shrubs, with net-veined leaves and regular hermaphrodite or dioecious flowers; ovules orthotropous. Example: *Smilax*.

Order IV, Pontederacææ.—Are aquatic herbs, with perfect, more or less irregular, blue flowers enclosed in a spathe; perianth-segments all petaloid. Example: *Pontederia vaginalis*.

Order V, Commelinacææ.—Are herbs, with jointed, often branching, leafy stems and irregular perfect flowers; outer leaves of perianth sepaloid, inner petaloid, each of three parts. Example: *Commelina communis*.

Order VI, Xyridææ.—Are sedge-like herbs, with flowers in sealy heads; stamens 3; anthers extrorse; perianth-segments 6, outer searious; ovary 1-celled. Example: *Xyris indica*.

Order VII, Juncacææ.—Are herbs of a sedgy or grass-like appearance, with often capitate inflorescence; perianth of six similar scale-like pieces; stamens 6, rarely 3. Example: *Flagillaria indica* (Ban-ehándar).

Order VIII, Palmææ.—Are usually arborescent plants, with simple unbranched stems, bearing large terminal clusters of mostly compound or deeply divided stalked leaves; flowers hermaphrodite or unisexual on a simple or branched spadix enclosed in a one or many valved spathe. Example: *Cocos nucifera*.

SERIES III.—*Nudifloræ.*

Flowers usually achlamydeous, with a dry searious perianth; ovary mostly apocarpous.

Order I, Pandanacææ.—Are trees or shrubs; with long, narrow leaves, imbricated in three spiral rows; flowers unisexual or polygamous, arranged on a simple or branched spadix, furnished with numerous spathe-like bracts; perianth none or consisting of a few scales. Example: *Pandanus odoratissimus*.

Order II, Aroidææ.—Are plants, with usually net-veined leaves; flowers mostly monœcious, sessile, arranged on a spadix; perianth wanting, or of 4 to 6 scales. Example: *Colocasia antiquorum*.

Order III, Typhacææ.—Are marsh herbs, with linear leaves and monœcious flowers, arranged on a spadix or in

heads; perianth none or reduced to a whorl of hairs; ovary solitary, 1-celled. Example: *Typha elephantina* (Hogla).

Order IV, Pistiaceae.—Are plants floating free on water, having one female and several male flowers within each spathe. Example: *Pistia stratiotes*.

Order V, Naidaceae.—Are slender floating or submerged plants, with jointed stems and long leaves; flowers inconspicuous, hermaphrodite, monœcious or diœcious; perianth of from 1 to 4 scaly pieces or none. Example: *Potamogeton indica*.

Order VI, Alismaceae.—Are aquatic plants, mostly with broad petiolate leaves and scape-like flowering stems; flowers in umbels, racemes, or panicles, perfect or monœcious; perianth of six pieces. Example: *Sagittaria* (Chotakat).

SERIES IV.—*Glumales*.

Perianth replaced by membranous scales; ovary always uniovulate or with uniovulate loculi.

Order I, Eriocauloneae.—Are aquatic or marsh herbs, with grass-like leaves; flowers arranged in dense heads, monœcious, sometimes diœcious; perianth glumaceous; ovary 1 to 3-celled. Example: *Leucocephala graminifolia*.

Order II, Cyperaceae.—Are grass-like herbs, with fibrous roots, and solid, frequently angular, stems; leaf-sheaths tubular, closed, without ligules; flowers perfect or unisexual. Example: *Cyperus rotundus* (Mútha).

Order III, Gramineae.—Are mostly herbaceous plants, rarely arborescent, usually with cylindrical hollow jointed stems, and narrow alternate leaves, with tubular sheaths, split down at the side, opposite to the blade, often with a ligule at its summit; flowers usually hermaphrodite, sometimes monœcious or polygamous. Example: Rice and Bamboo.

DETAILS OF MONOCOTYLEDONOUS ORDERS.

Hydrocharideae

Are aquatic herbs, with usually unisexual regular flowers, issuing from a spathe at the end of the scape-like peduncles;

the perianth consists of one or two whorls, the inner, when present, petaloid; ovary inferior; seeds without endosperm.

The combination of the characters of this order serves to distinguish it from all other monocotyledons, while the characters taken separately connect it with many.

Hydrilla verticellata is a submerged water plant with filiform jointed stems, sometimes creeping, sometimes floating below the surface of the water; leaves sessile, verticillate; flowers small, white, axillary. This plant is used by sugar-refiners for the purpose of purifying sugar; the moisture which it contains slowly percolates through the sugar, carrying off impurities.

Fig. 175.

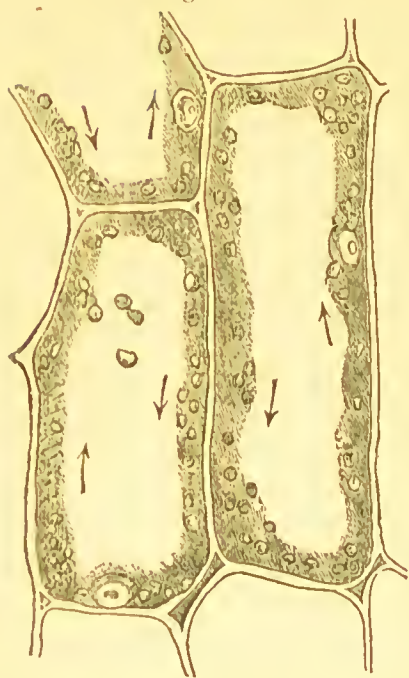


Vallisneria spiralis (see Fig. 175) is a submerged water plant, with radicle grass-like leaves; it grows abundantly in fresh water tanks; the female flowers are borne upon long spirally-twisted peduncles, which permit them to reach the surface, where they come into contact with the detached floating male flowers.

Plants of *Vallisneria spiralis* (reduced).

V. octandra (Sheyálá) is also very common; also *V. alternifolia* (Rasnajnanji). *Ottellia alismoides* (Pani-kalá) is an aquatic annual, with radical, petiolate, cordate, waved leaves and whitish flowers, which appear during the rains; capsule oblong, six, grooved, crowned with the withered perianth.

Fig. 176.



Cells from the leaf of *Vallisneria spiralis*; the round bodies are grains of chlorophyll, the arrows denote the direction of the currents of protoplasm (after Thomé).

The submerged leaves of several species of this order are well suited to show the rotation of the cell-sap (see Fig. 176).

Seitamineæ

Are herbs, often very robust, and sometimes arborescent, having large leaves and irregular, usually brilliantly-coloured, flowers; fertile stamen 1 (or 5 in the Suborder Musaceæ), with five petal-like staminodes; ovary inferior, 3-celled.

This order is usually divided into three suborders: *Zingiberaceæ*, *Marantaceæ*, and *Musaceæ*. The Suborder *Zingiberaceæ* is distinguished from the other two by the fertile stamen being posterior, and the anther 2-celled, and by

the embryo being contained in a special sac or vitellus. Suborder 2, *Marantaceæ*, has the outer circle of stamens more or less developed in a petaloid form, and but one lateral stamen of the inner circle fertile. Suborder 3, *Musaceæ*, has usually five fertile stamens. From the great prevalence of these plants in the Indo-Malayan region, and also in the neighbouring islands of Java, Borneo, New Guinea, &c., this region has received the name of the "*Region of the Seitamineæ*." The principal plants of the suborder of *Zingiberaceæ* are *Zingiber officinale* (Adruk, adá): it is universally cultivated in India for the sake of its rhizomes, the flowers are small whitish purple, and appear in the rains. *Cureuma longa* (Haldi) is likewise cultivated all over India; the flowers are large yellowish white, and appear in the rains. *C. amada* has small yellowish white flowers, which appear during the rainy season; the fresh root has the smell of a green mango. *Amonum carda-*

momum has flowers of a light rose colour, tinged with yellow, which appear in April; the seeds are agreeably aromatic.

Elettaria cardamomum (Elachi), the seeds of which are commonly known as cardamoms. *Hedychium coronarium* (Dulál-chámpá) is a native of various parts of Bengal; it flowers during the rains; the flowers are handsome, large, pure white, and very fragrant; it is the most charming plant of this order. *Costus speciosus* is a native of moist shady places; it flowers during the wet season.

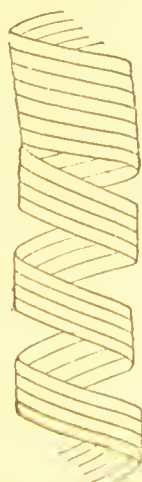
The principal plants of the Suborder *Marantaceæ* are *Maranta arundinacea* (Arrowroot); its flowers are pure white and appear in the rains; arrowroot is prepared from the rhizomes by maceration in water.

M. dichotoma (Múktapáti) is a native of various parts of India; flowering time the hot season. Mats made of the split stems (sital-páti) are smooth and particularly cool; they are in general use everywhere in India.

Canna Indica (Indian shot), common over India; it is in flower and seed most part of the year; there are two common varieties—one with red, the other with yellow, flowers.

The principal plants of the Suborder *Musaceæ* are *Musa paradisiaca*, indigenous in the forests of Chittagong and Cachar; the number of cultivated varieties is very large.

Fig. 177.



Spiral thickening of a vessel from a leaf of the plantain (magnified).

Fig. 178.

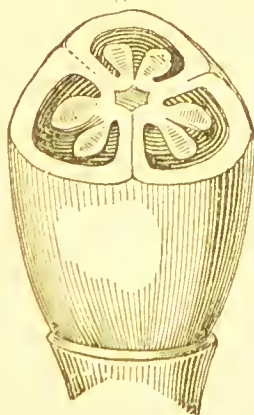
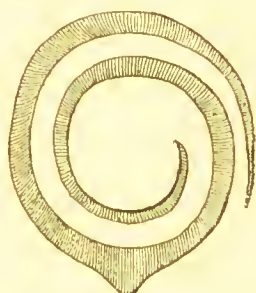


Diagram showing the multilocular compound ovary of the plantain.

Fig. 179.

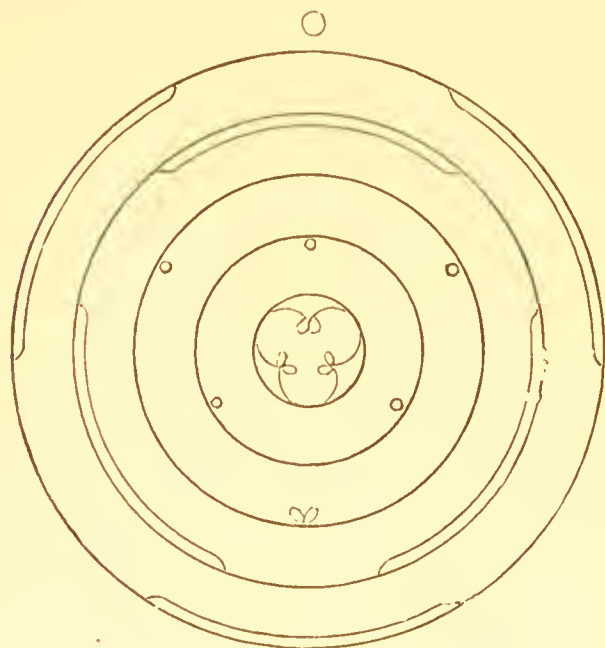


Convolute vernation of a leaf of the plantain.

The fibres of the petioles of *M. textilis* is known as Manilla hemp. Spiral vessels can be well seen by examining a portion of the leaf of the common plantain under the microscope (see Fig. 177).

Other genera are: *Kampfer*, L.; *Alpinia*, L.; *Globba*, L.; *Phrynium*, Willd.; *Calathea*, Meyr.; *Heliconia*, L.; *Ravenala*, Adans.

Fig. 180.



Orchideæ

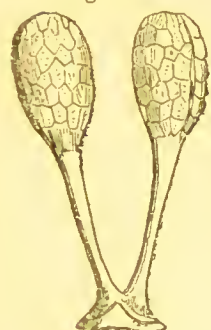
Are herbs, with regular flowers; perianth in two whorls; stamen 1 (or 2 in the tribe *Cypripediæ*) gynandrous; pollen cohering into wax-like or mealy masses; ovary inferior, 1-celled, with parietal placentas; seeds extremely numerous and small.

Diagram of the flower of an Orchid.

The flowers of *Orchideæ* can be derived from the type represented in Fig. 171. although their external form is so remarkably different; of the andrœcium only a single stamen is completely developed in most orchids, *viz.*, the anterior one of the outer whorl, the others being abortive.

The suppression of 2 out of 3 stamens connects this order with *Marantaceæ* and *Zingiberaceæ*. The orchids, however, differ very considerably from all other monocotyledons;—1st, in the usually great irregularity of the perianth, especially in the posterior member of the inner circle (the labellum; frequently anterior by the twisting of the ovary), which is sometimes developed into a spur or nectary; 2nd, in the filament being coherent with the style forming

the column; 3rd, in the ridges occurring in the column and labellum, which are believed to be abortive stamens, giving rise to the opinion that the elements of two circles of stamens exist in this order, of which five are usually suppressed; 4th, in the prolongation of the upper edge of the stigma (the *rostellum*); and 5th and lastly, in the pollen being less developed than usual; the process of sub-division into distinct pollen-grains being arrested, so that it remains in masses (*pollinia*) (see Fig. 181) sometimes provided with a pedicel or *caudicle*, which adheres



Pollinia with caudicles and gland (magnified).

to a *gland* or glands at the apex of the stigma. The lobellum, rostellum, and caudicle are sometimes endowed with contractile properties. The Orchideæ are terrestrial in temperate climates; in warm and moist climates they are frequently epiphytic, hanging on the branches of trees, or even attaching themselves to rocks, &c. They are most abundant in damp situations.

The following classification of the genera in tribes has lately been proposed by Mr. Bentham, in the journal of the Linnean Society:—

Fig. 182.



Flower and portion of a leaf of *Vanda*.

Tribe 1, Epidendreae.—Anther 1; dorsal operculate, usually incumbent, with the cells distinct and parallel; pollinia waxy, in one or two series parallel, two or four in each series (1—4 in each cell), free or joined in each cell by a viscous substance or a granular appendage, very rarely attached to the rostellum.

This tribe is formed by the union of Lindley's *Malaxideæ* and *Epidendreae*, which he had distinguished by the absence or presence of a caudicle to the pollen masses; but this character is very obscure in many genera.

Mr. Bentham divides this tribe into nine subtribes, based mainly on the vegetative characters and the number of pollinia. The subtribe *Dendrobieæ* is the most profusely represented in India, especially the large genus *Dendrobium*, which numbers some three hundred species, ranging from India and Japan to Australia and New Zealand. *D. Pierardii* is one of the commonest orchids in the plains of Bengal, growing generally on mango trees: it has jointed stems, 2 to 5 feet long; alternate, sessile, oblong lanceolate leaves, and large showy yellowish white flowers, issuing from the nodes of the stem. The subtribe *Cœlogyneæ* is also largely represented in India. Several handsome species of the genus grow on rocks in the Himalayas at an elevation of 4,000 to 8,000 feet.

Tribe 2, Vandeeæ.—Anther 1; dorsal operculate, lying upon or against the rostellum, with the cells very often confluent during flowering; pollinia waxy, very often 2, obliquely or transversely grooved, or 4, in pairs, fore and aft; anther-case deciduous; pollinia with a gland or plate constituting the pollinarium. This tribe is again divided into eight subtribes, whereof the *Sarcantheæ* are the most numerous and conspicuous in India. *Vanda teres*, *V. Roxburghii*, and *Saccolabium guttatum* are common examples in Bengal. The first grows only in the grass of the Sunderbuns; and the second is very common on mango and other trees: it has dusky, ferruginous flowers, with a mixture of yellow and white, produced during the rainy season. The *Saccolabium* grows on trees in the tidal swamps.

Tribe 3, Neottieæ.—Anther 1; dorsal operculate or erect and persistent, with distinct parallel cells; pollinia granu-

lar or powdery; stems not thickened into pseudobulbs. With this Mr. Bentham combines Lindley's *Arethuseæ*.

Tribe 4, Ophrydeæ.—Anther 1; dorsal erect, prone or reflexed, with distinct, parallel or divergent cells, adnate to the anther-bed, and often continued at the base into the rostellum; pollinia granular, produced downwards in each cell into a caudicle.

Platanthera susannæ and several species of *Habenaria* represent this tribe, which consists almost entirely of ground-orchids.

Tribe 5, Cypripediæ.—Anthers 2, sessile at the sides of the rostellum, or stalked.

The genus *Cypripedium* is represented by three or four species in Assam. They are ground-orchids, remarkable for their large slipper-shaped labellum.

Aspostasia has been regarded as a separate order, but like some other *Cypripediæ* it only differs from the bulk of orchids in having a 3-celled ovary.

Amaryllideæ

Are herbs having leaves with veins diverging from the base and parallel to the mid-rib, with a 6-leaved petaloid perianth and 6 stamens; ovary inferior, 3-celled.

This epigynous order contrasts with the hypogynous *Liliaceæ*.

The order includes many ornamental species prized in gardens. *Crinum Asiaticum* (Bara kánur) (see Fig. 183) is a large bulbous herb common in gardens, with smooth, linear, lanceolate radicle leaves and large umbels of regular white flowers, which appear during the wet season, and more or less the whole year. In this species the bulb is often prolonged above the surface of the ground, so as to form a short trunk. *Amaryllis grandiflora* is common in gardens; the flowers are large flesh-coloured.

Agave Americana is now naturalized in most parts of India; preparations of the root are used medicinally by the Mexicans. *Curculigo orchiioides* is a small plant common in most parts of India; the roots are tuberous, about 4 inches long, having a slightly bitter taste; they are used in medicine. (This differs from the normal *Amaryllidaceæ* in

Fig. 183.

*Crinum Asiaticum*, reduced (after Oliver).

Fig. 184.

Scape of *Amaryllis*
with 2 flowers.

having a 1-celled ovary with three parietal placentas, and is usually referred to the Hypoxideæ, which some botanists regard as an independent order, while others would class them as a suborder of the present order.)

Dioscorideæ

Are plants with twining stems (see section stems, page 12) and net-veined leaves; flowers regular, diœcious; stamens 6; ovary 3-celled.

The twining habit and net-veined leaves distinguish this order from the Amaryllidaceæ. *Dioscorea globosa* (Chupri-

Fig. 185.

Versatile
anther of
Amaryllis.

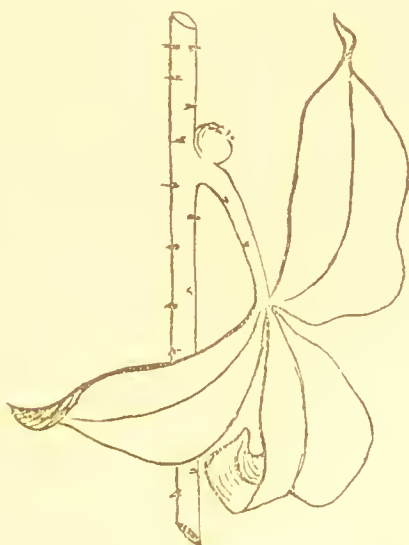
álú) is the most esteemed of all the yams; the tubers are roundish white; the stems twine to the right (dextrorse) like the English hop; the leaves are alternate and opposite cordate, and the flowers are small white; they appear during the rains. *D. alata* (Kham álú) is also much cultivated; the stems twine as in *D. globosa*; flowering time the close of the rains: the tubers are sometimes of great size. *D. rubella* (Garaniya álú) is also commonly cultivated. There are several other common species. Minute green bulbils are often borne in the axils of the leaves of some species of *Dioscorea* (see section stem, page 16).

Fig. 186.



Climbing stem of
Dioscorea, twining
to the right.

Fig. 187.



Portion of stem of *Dioscorea*, with
a bulbil in the axil of the leaf.

Bromeliaceae

Are herbs, with fleshy or dry crowded leaves, sheathing at the base, usually covered with scales; the parts of the outer whorl coherent, of the inner distinct; stamens 6; ovary 3-celled, free or adherent.

Fig. 188.



Polythalamic fruit
(Sorosis) of *Ananas sativus*.

Fig. 189.



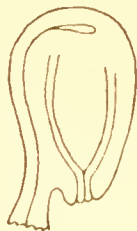
Petaloidperianth of a Lily.

Fig. 190.



Orthotropous
ovule as in
Smilacæ.

Fig. 191.



Anatropous
ovule as in
Liliacæ.

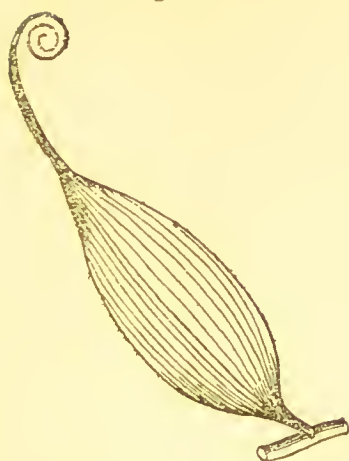
Many of the Bromeliaceæ have free ovaries. The Bromeliaceæ are wholly American, and the only plant of this order common in India is *Ananas sativus* (see Fig. 188); which flowers about the beginning of the hot season. This plant is important, not only on account of its delicious fruit, but also on account of the fibres, which abound in the leaves; from which cloth has been manufactured as fine as muslin. Most of these plants are epiphytic, appearing to be capable of obtaining the greater part of their nourishment from the atmosphere.

Liliacæ

Are herbs, with parallel veined leaves and regular 6-androus flowers; anthers introrse; perianth petaloid, 6-merous; ovary 3-celled with central placentation; ovules anatropous; seeds with fleshy endosperm.

The Liliacæ have widely spreading relations, although the typical forms are at once distinguishable; the superior ovary separates them from Amaryllidacæ: the tribe Asparageæ closely resembles the Smilacæ in appearance and general character; all the Liliacæ, however, have anatropous or amphitropous ovules; whereas in Smilacæ the ovules are orthotropous.

Fig. 192.

A curvinerved leaf, ending in tendril, of *Gloriosa superba*.

Gloriosa superba (Ulátchandál) has a climbing herbaceous stem; the mid-ribs of the leaf terminate in tendrils (see Fig. 192); the flowers are large, and the style has a peculiar sensitive motion; these plants appear during the rainy season.

Lilium longifolium is a common garden plant; the flowers are large white and fragrant, and appear about March. *Polianthes tuberosa* (Rajaní gandhá)

is a common garden perennial, celebrated for the fragrance of its large white flowers. The leaves of *Sansevieria Roxburghiana* (Múrbá) yield the tenaceous fibre, termed bowstring hemp. *S. guineensis* and *S. capensis* are common in gardens. The former has peculiar dark green ribbed horn-like leaves.

Fig. 193.



Scaly bulb of Lily.

Fig. 194.



Tunicated bulb of Onion.

Aloë perfoliata (Ghrīto kumārī) is common in dry situations. *A. soccotrina* and *A. vulgaris* are used medicinally. *Yucca gloriosa* has strap-shaped, sharp-pointed leaves and greenish white flowers.

Allium sativa (Rashun) is cultivated in gardens ; the flowers are small white. *A. cepa* (Peyaj) (see Fig. 194) is largely cultivated everywhere ; the flowers are small, white, and appear in the cold season. *Asparagus officinalis* (Hillúá) (see Fig. 195) is cultivated in gardens ; the flowers are of a yellowish green colour, and appear in March and April.

Fig. 195.

Portion of a branch of *Asparagus*.

A. racemosus (Sat-múlī) is a scandent, slender, shrubby plant, a native of various parts of India. Flowering time the cold season ; the flowers are pure white, and delightfully fragrant.

Urginea maritima is the medicinal squill, valuable as an expectorant and diuretic. *U. indica* inhabits the sandy shores of the peninsula of India. The bulb is used for the same purpose as that of *U. maritima*.

The bulbs of *Ledebouria hyacinthoides* grow in sandy plains, in many parts of India, and resemble squills in general appearance, but are of a smaller size. *Peliosanthes teta* is a perennial plant, with plaited radical leaves and small green flowers.

Other genera are: *Dracæna*, *Cholchicum*, *Hyacinthus*, &c.

Smilacææ

Are herbs or climbing shrubs, with net-veined leaves and regular hermaphrodite or diœcious flowers; perianth from 6—10 parted; ovary superior, from 3—5-celled; ovules orthotropous; seeds with hard, fleshy endosperm.

These plants differ from those of Liliacææ, in having net-veined leaves, climbing stems, mostly small diœcious flowers, and orthotropous ovules. In foliage and habit they closely resemble the Dioscoreæ, from which they are easily distinguished by their superior ovary, and as far as the Indian genera are concerned, by their baccate fruit. *Smilax ovalifolia* (Kúmáriká) is common in hedges and wild places. The stems are round, the leaves oval, smooth, from 5—7-nerved; the flowers are small, and of a greenish colour; they appear during the hot season. Sarsaparilla, used in medicine, is the dried root of *Smilax officinalis*. The roots of *S. lanceafolia* and *S. glabra* are used in this country medicinally in cases of rheumatism, &c.

Pontederiacææ

Are aquatic herbs, with perfect more or less irregular flowers, sometimes subtended by a spathe; the perianth is persistent, petaloid, 6-merous, rolling inwards after flowering; stamens 3—6, mostly unsymmetrical; ovary superior, 3-celled; seeds with mealy endosperm.

This order is separated from Liliacææ chiefly by its irregular flowers, by the persistent perianth rolling inwards after flowering, and by the mealy endosperm of its seeds.

Pontederia vaginalis (Nauká) is a native of the borders of tanks and marshy places; it flowers during the rains; leaves radicle, narrow, cordate, entire, smooth; flowers blue. The order is a very small one. The plants are chiefly confined to the stagnant waters of hot countries.

Commelinaceæ

Are herbs, with jointed, often branching, leafy stems, perfect flowers, clustered within one or two large coneave bracts; outer leaves of perianth sepaloid, inner petaloid, each of three parts; stamens 6, all fertile or some abortive, often peculiar in form; ovary superior, from 2—3-celled; seeds with fleshy endosperm.

The jointed stem and the outer sepaloid perianth-segments serve to distinguish these plants from their nearest allies. *Commelina communis* (Jatá kánehará) is common over the low moist parts of India; flowering during the rainy season. The leaves are ovate, lanceolate, acute with waved margins, and involucre many flowered.

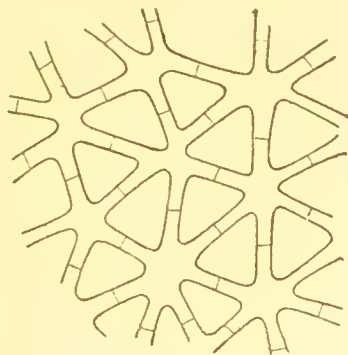
C. bengalensis (Kanchará) is smaller and not so common as the last mentioned species; the leaves are alternate, cordate, hairy; the involucre are 3-flowered; the flowers are small and bright blue. *Tradescantia discolor* is a common garden plant, about 2 feet in height, with sharp pointed leaves, of a green colour, bordered with reddish purple; flowers small, white. The protoplasm, nucleus, rotation of the cell-sap, etc., are well seen in the moniliform hairs of the stamens of this plant. *Cyanotis axillaris* (Bághanulá) is an annual creeping plant with axillary flowers, a native of moist pasture ground, borders of rice-fields, &c.; appearing and flowering during the wet and cold season.

Juncaceæ

Are herbs of a sedgy or grass-like appearance, with hollow or transversely divided, rarely flat, leaves, and often capitate inflorescence; perianth regular, persistent, of six dry or scarious segments; stamens 6; ovary superior, from 1—3-celled; seeds with fleshy, horny endosperm.

The sedge-like habit of these plants and the scarious nature of the segments of the perianth distinguish them from Liliaceæ. *Flagellaria indica* (Ban-chándar) is a long straggling prennial plant, flowering during the early part of the rains; flowers are small, white. *Juncus bufonius* is a small tufted annual plant with inconspicuous flowers, scattered along the stems. The Juncaceæ is a large order; the species are chiefly natives of cold and temperate regions. The tissue of the leaves

Fig. 196.



Stellate cells from a leaf of *Juncus* (magnified).

has a beautiful microscopic structure, being formed of stelliform cells (see Fig. 196).

Palmææ

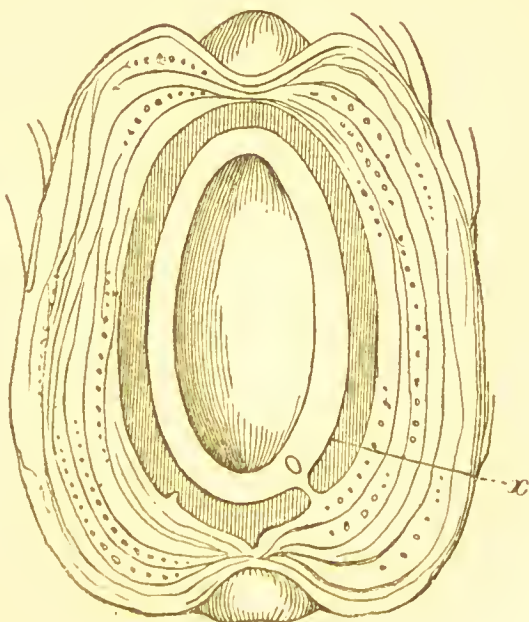
Are woody, arborescent trailing or climbing plants, usually with a simple unbranched stem, bearing scattered or large

Fig. 197.



Compound spadix and spathe of a Palm.

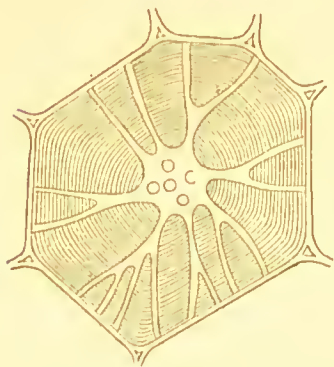
Fig. 198.



Section of a Coconut.

terminal clusters of mostly deeply, palmately or pinnately divided, rarely compound, petiolate leaves; flowers usually diclinous and often dioecious, sometimes hermaphrodite on a simple or branched spadix (see Fig. 197), enclosed in a one or many valved spathe; perianth 6-leaved in two circles; stamens usually 6; ovary from 1—3-celled with fleshy or hard, often ruminated, endosperm in which the minute embryo is superficially embedded (see Fig. 198).

Fig. 199.



Cell from the shell of a coconut showing the excessive thickening of the cell-wall (magnified).

The fruit in *Cocos* and *Areca* is 1-celled from the suppression of two of the carpels; it is 3-celled in *Borassus*, *Caryota*, *Calamus*, *Arenga*, etc.

The structure of the pericarp is particularly variable: in *Cocos* the epicarp is fibrous, affording the coir of commerce; the endocarp is a hard shell and is used for various purposes (see Fig. 199). In *Phoenix* the endocarp is fleshy and sweet.

This order is a very large one, and constitutes one of the most striking features in the vegetation of most tropical regions. It consists of upwards of 100 genera, embracing about one thousand species, only about half-a-dozen of which occur in temperate regions; many of them yield useful products, and some of them supply nearly all the wants of the inhabitants of certain countries.

These plants form a very natural group, separated by distinct characters from the rest of the monocotyledons. There is a connection with some of the Aroideæ and Liliaceæ, but the habit and position of the embryo at once distinguishes them. *Areca catechu* (Guya, súpári) is one of the handsomest palms in India; it flowers during the hot season; the flowers are monoecious. The endosperm is ruminated (Betel nut).

Borassus flabelliformis (Tál).—This palm is common all over India; it flowers during the hot season; the flowers are dioecious; the leaves are employed for making punkahs;

and the wood is used for various purposes. The fruit is drupaceous. *Phoenix sylvestris* (Khájúr) is common all over India: the juice (Tári) of the tree is usually boiled down into sugar; the flowers are dioecious. *P. dactylifera* is the date tree.

Cocos nucifera (Narikel): flowers during the hot season; it is largely cultivated for its fruit.

Calamus rotang (Bet) is a dioecious plant; the fruit is covered with numerous hard imbricated scales; the flexible stems of this and other species are largely exported from the Malayan peninsula for cane-work.

Caryota urens is common on the western coast of the Madras peninsula; it has compoundly segmented leaves, and an inferior sort of sago is prepared from the pith.

Other genera are: *Oreodoxa*, *Arenga*, *Zalacca*, *Sugus*, *Corypha*, *Chamærops*, &c.

Pandanaceæ

Are trees or shrubs, often branching; leaves imbricated in three spiral rows, mostly linear lanceolate; flowers unisexual or polygamous, arranged on a very dense, simple or branched, spadix, furnished with numerous spathe-like bracts; male inflorescence usually branched, female inflorescence simple; perianth none, or consisting of a few scales; stamens numerous; ovary 1-celled; seeds with the minute embryo embedded near the base of the fleshy endosperm.

The branching stem and large aerial roots distinguish Pandanaceæ from Palms. The narrow undivided leaves are spirally developed on the stem; hence the name Serewpines, by which they are commonly known. *Pandanus odoratissimus* (Keyá) attains to the height of about 15 feet, the stem at half that height branching into several sub-erect arms terminated by thick foliage; it flowers chiefly during the rainy season. The flowers are dioecious, small, and delightfully fragrant. *Pandanus foetidus* (Keyákántá) is sometimes used for making hedges; it flowers during the cold season. *Nipa fruticans* grows abundantly in the Sunderbunds: it is regarded by some botanists as the type of a distinct order, having the pinnate leaves of a Palm and the inflorescence of a Pandanus.

Aroideæ

Are plants, with usually net-veined, often divided leaves ; flowers monœcious, more rarely dicecious, or sometimes bisexual, usually sessile on a spadix, enclosed in, or subtended by, a spathe ; perianth wanting or of 4—6 seales ; seeds usually with the embryo embedded in the axis of mealy or fleshy endosperm.

The peculiar thickened fleshy flowering spadix densely covered with flowers, together with the spathe, gives this group a character of habit which is generally very distinct. The Pistiaceæ are closely related to these plants,

Fig. 200.



Inflorescence of an *Aroid*
surrounded by a spathe.

and are regarded as the simplest form of Aroids. *Typhonium orixense* (Ghetkachú) is very common everywhere in Bengal ; the leaves are radicle, deeply 3-lobed ; the flowers appear at the beginning of the rains ; the spathe is shorter than the petioles, striated and erect, the inside red, the outside green. *Amorphophallus campanulatus* (Ol) is a plant with large segmented leaves ; the flowers appear in June ; the eorns, which are dug up after the leaves have withered, are largely used as an article of food. *Colocasia antiquorum* (Kachú) is an extensively cultivated perennial herb, with large radicle peltate-sagittate leaves ; the flowers are monœcious, enclosed in a yellow spathe. The lower portion of the spadix is covered with female flowers ; above the female flowers are some abortive pistils, then a number of closely packed male flowers, each reduced to a single 2-celled anther opening by minute pores at the apex. The spadix is prolonged above the staminate flowers into a sterile mass of tissue. There are several varieties of this species.

C. indica (Mán-kachú) is much cultivated in Bengal for its esculent stems and corms ; it flowers at the close of the rains and beginning of the cold season.

Fig. 201.

Section of a corm of *Arum*.

Pothos scandens, an epiphyte, is a native of Chittagong ; the leaves are alternate, petioled, lanceolate, entire, smooth ; the flowers are hermaphrodite.

Acorus calamus, a plant common in moist sites throughout Asia, Europe, and North America. The rhizome has long been held in esteem as a tonic, &c. *Richardia orthopica* (Lily of the Nile) is cultivated in Himalayan stations. The plants of this order are most abundant in the tropics ; the juices are generally acrid and dangerous, but heat dissipates the noxious principles.

Other genera are : *Cryptocoryne*, *Alocasia*, *Caladium*, *Aglaonema*, *Scindapsus*, *Arum*, &c.

Typhaceæ

Are marsh herbs, with linear leaves and monœcious flowers, arranged in spikes or heads ; perianth none, or reduced to scales or bristles ; ovary solitary, 1-celled ; seeds with the embryo embedded in the axis of the mealy endosperm. The habit and general appearance of these plants resemble those of *Cyperacæ*.

Typha elephantina (Hoglá) is a perennial herb, growing on the borders of tanks and marshy places, which do

not dry up during the hot season; the culms are from 6 to 12 feet high; the leaves are long, ensiform, and smooth; and are sometimes used for making mats. The abundant pollen is nutritious, and is made into a kind of bread in Western India, New Zealand, and elsewhere.

T. angustifolia (Rám hoglá) is smaller than the last mentioned species, but is found in similar places.

Pistiaceæ

Are plants floating free on water with monœcious flowers, surrounded by a spathe; each spathe containing one female flower and two or more male flowers; stamens definite, sometimes monadelphous; ovary 1-celled; embryo straight, in the axis of fleshy endosperm.

These plants are sometimes regarded as the simplest forms of the Aroids. *Pistia stratiotes* (Tákápáná) (see Fig. 203) is found floating on pools of stagnant water in most parts of India; flowering time the hot season. The flowers are monœcious, and are very beautiful when examined with an one-inch object glass.

Fig. 202.

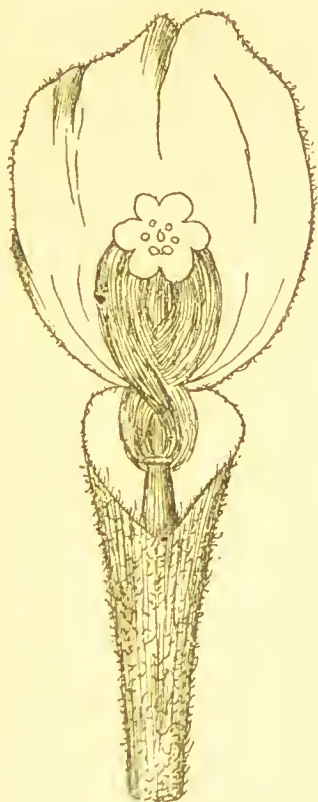


Plants of *Pistia*; the smaller one to the right is of later growth, and is connected with the parent plant by a runner.

In *Lemna orbiculata* (see Fig. 204) the leaves are minute, sessile, orbicular, flat on both sides, from 2 to 3 together. *Wolffia Delilii* is very minute and rootless; the

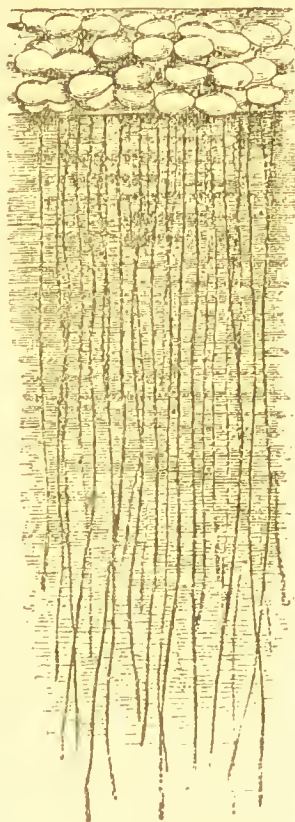
leaves are globose, one or two together; and occurs with *L. orbiculata* in every tank and pool of stagnant water in Bengal, forming a green scum over the surface.

Fig. 203.



Inflorescence of *Pistia stratiotes* (magnified).

Fig. 204.



Aquatic roots of *Lemna*.

L. cruciata is generally found under the surface of the water in tanks; the leaves are petioled, lanceolate. *Pistia* is very widely dispersed in warm countries, whereas *Lemna* is equally common in hot and cold countries. These plants are useful in tending to purify the stagnant pools and ditches in which they abound. The genus *Lemna* is one of the simplest representatives of the Phanerogamia.

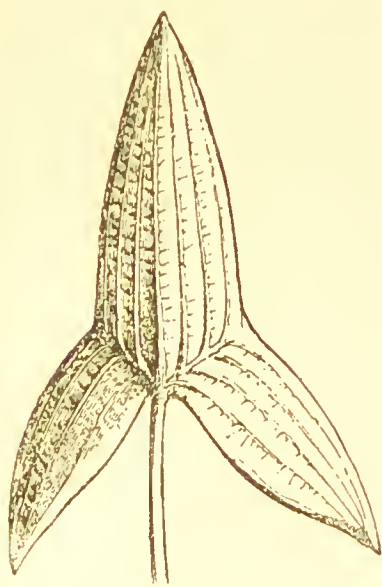
Naiadaceae

Are floating or submerged branching plants growing in fresh or salt water; flowers inconspicuous, hermaphrodite,

monœcious, or diœcious; perianth of 1—4 scaly pieces or none; stamens definite; pistil free, of one or more carpels; ovary 1-celled; ovule solitary; seeds without endosperm.

This order agrees with Hydrocharidaceæ and Alismaceæ in the structure of the seeds, but differs in wanting a conspicuous perianth, and in the form of the inflorescence; the structure of these plants is generally very simple. *Potamogeton indicum* is an aquatic herb, with floating, oblong or elliptical glabrous, many nerved leaves; a native of the borders of fresh water lakes and ditches; flowering time February and March. The flowers are small, numerous, of a green colour, and are borne in dense-spikes. *Spathium chinense* (Ghechú) is a native of shallow standing water, and appears and flowers during the rains. The flowers are small, purplish white, with blue anthers. The structure of these plants is generally very simple, consisting chiefly of tissue of very delicate organization. The genus *Zostera* is met with in the sea in all parts of the world.

Fig. 205.



Sagittate leaf of *Sagittaria sagittifolia*.

Alismaceæ

Are aquatic plants, mostly with broad, petiolate leaves and scapose inflorescence; flowers in racemes, umbels or panicles, perfect or monœcious; perianth of six pieces—outer three herbaceous, inner three petaloid; ovaries several, more or less distinct; seeds without endosperm.

Some of these plants bear considerable resemblance to the dicotyledonous order Ranunculaceæ. They can be distinguished from the Commelinaceæ, to which they have some similarity, by their tufter radical leaves, scapose inflorescence, apocarpous fruit, &c.

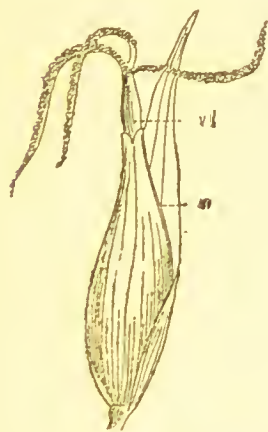
Sagittaria sagittifolia (Chota-kat) is a polygamous plant growing in marshy places, where it flowers in February, March, and April. The leaves are sagittate (see Fig. 205), the scape simple, and the flowers pure white, with a purplish base. *S. obtusifolia* (Bara-kat) is a common annual growing in swampy places, with radicle, erect, sagittate obtuse leaves; it flowers during the cold season. The scapes are from 2 to 4 feet high; flowers numerous, small, white; the lower flowers of the inflorescence are usually female.

Other genera are: *Alisma*, *Butomus*, and *Limnocharis*.

Cyperaceæ

Are grass-like herbs, with fibrous roots and solid, frequently angular stems; leaf-sheaths, closed without a ligule at the apex; flowers perfect or unisexual, each with a solitary bract or glume; perianth none or existing in the female flowers, in the form of a membranous covering, called perigynium (see Fig. 206); stamens mostly 3; ovary superior, 1-celled; seed with a lenticular embryo enclosed in the base of the endosperm. The solid, usually angular, stems, the closed leaf-sheaths, and the reduction of the floral envelopes to a single bract or glume, distinguishes these

Fig. 206.



Female flower of a sedge.

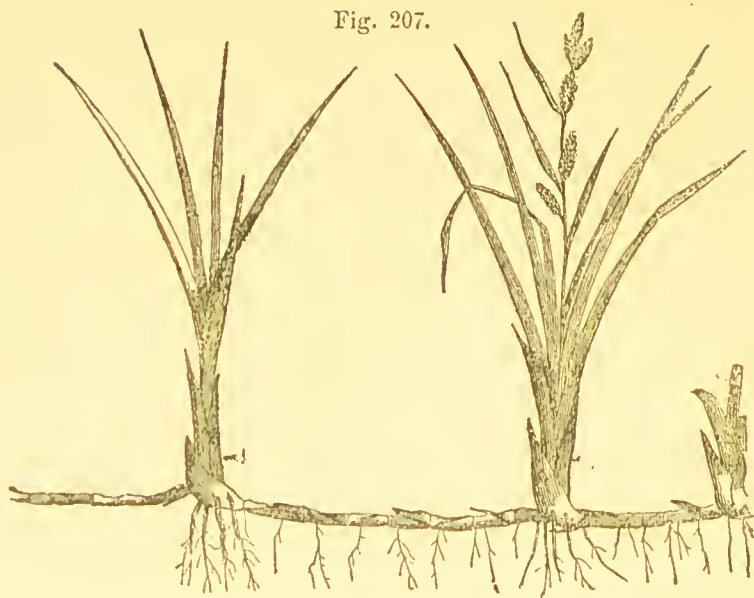
plants from the Gramineæ, which they resemble in many respects.

Cyperus rotundus (Múlha) is by far the most common species in India; it grows abundantly everywhere; culms erect, from 1—2 feet high, three sided, smooth; umbels terminal, surrounded by a 3-leaved involuere.

Cyperus inundatus (Pátí) is found in great abundance on the low banks of rivers; it thrives most luxuriantly where the tide rises over it.

Papyrus pangorei (Mádúr kátí) is common in ditches and on the borders of marshy places during the rains:

Fig. 207.

Creeping stem of *Carex*.

what is known as "Calcutta matting" is made from the culms of this plant.

Papyrus antiquorum is a tall sedge, celebrated as having furnished the ancients with a kind of paper made from the pith.

Other genera are: *Carex*, *Scleria*, *Scirpus*, *Mariscus*: *Kyllinga*, *Courtoisia*, *Fimbristylis*, *Isolepis*, *Flurena*, *Rhynchospora*.

Gramineæ

Are mostly herbaceous plants, rarely arborescent, usually with hollow jointed stems, narrow alternate leaves, with sheaths split down at the side, opposite to the blade, often with a ligule at its summit; flowers usually hermaphrodite, sometimes monœcious or polygamous, either solitary or arranged in spikelets; spikelets one to many flowered, consisting of a number of bracts and the essential organs of reproduction without any perianth, or the latter represented by one or more, usually very minute, organs called lodicules. Each spikelet commonly has two or more outer or empty bracts (glumes), one (flowering glume) below each flower, and a pale enclosing each flower. The pale

differs from glumes in having no central nerve; and it usually has two lateral ones. Stamens usually 3 (in Rice and Bamboo there are 6); ovary superior, 1-celled; embryo lying at one side at the base of the faranaceous endosperm.

Fig. 208.

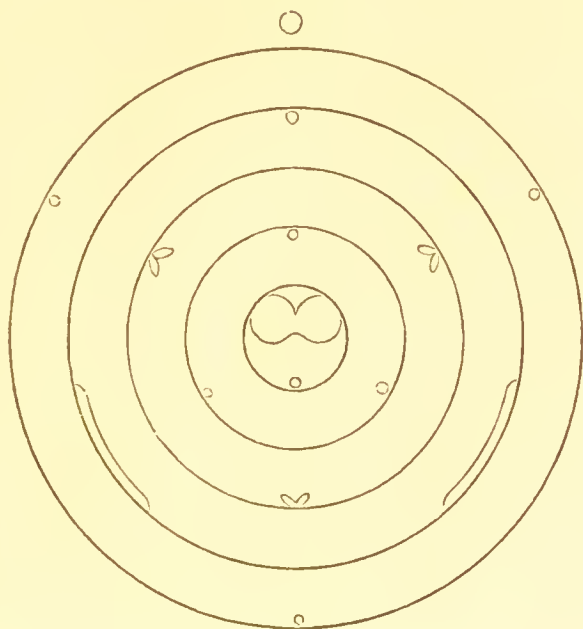


Diagram of the flower of a grass.

The flowers of most grasses may be deduced as is shown in Fig. 208 on the theory of the abortion of certain parts from the typical Monocotyledonous flower represented in Fig. 171, which is itself the typical diagram of *Liliaceæ*. The posterior leaf of the inner perianth whorl, the outer perianth whorl, the whole of the inner whorl of stamens, and the anterior carpel are wanting.

The hollow jointed stems, the leaf-sheaths split down at the side opposite to the blade, and the ligule at the base of the blade, &c., distinguish this order from the Cyperaceæ. *Sugar canes* (Uk), however, have solid stems, and the rhizomes of ordinary grasses are also commonly solid. The remarkable awn which is produced in the flowering glumes of many grasses is usually regarded as a barren development of the axis of the spikelet, which would make the inner palea the subtending bract of the flower; the ligule is generally regarded as an excrescence from the upper parts of the sheathing petiole. The main value of this order

Fig. 209.



Fruit of Rice, showing the glumes some with and some without awns.

is in the seeds or more properly the fruits, especially of what are called the cereal grains, such as Rice, Maize, Wheat, Rye, Barley, and Oats.

Mr. Bentham has lately proposed a new or modified classification of grasses, of which the following is an outline:—

SERIES A.—*Panicaceæ*.

Spikelet jointed to the pedicel below the outer glumes, with one fertile flower, with or without a male or barren flower below it.

Tribe 1, Paniceæ.—Spikelets hermaphrodite, rarely unisexual by abortion, spicate or paniculate; rachis of the inflorescence not jointed; flowering glume not awned, hardened in fruit or at least stiffer than the outer ones.

One of the largest tribes, particularly numerous in tropical countries. Example: *Paspalum*, *Panicum*, *Pennisetum*, *Oplismenus*, *Setaria*, etc.

Panicum commutatum (Mákar-jálí) is a common grass of which cattle are very fond.

Tribe 2, Maydeæ.—Spikelets unisexual; the male terminal, spicate or paniculate, the females spicate at the base of the males or in a separate inflorescence, disjoining from the rachis, except in *Zea*.

A very small tribe, including the genera *Coix* and *Zea*.

Zea mays (Bhúta), the largest cereal; it is cultivated in various parts of India; the flowers are monœcious—a rare occurrence among the Gramineæ.

Tribe 3, Oryzææ.—Spikelets hermaphrodite or rarely unisexual, paniculate or spicate; rachis of the inflorescence not jointed; scale or glume next the flower 1-nerved or keeled, not 2-nerved as in most grasses.

Also a small tribe, yet it includes the important genus *Oryza*.

Oriza sativa (Dhán); the flowers of this well-known useful cereal have 6 stamens.

Tribe 4, Tristegineæ.—Spikelets hermaphrodite, solitary geminate or fasciculate along the branchlets of the inflorescence; empty glumes awned or awnless; flowering glume transparent or membranous, awnless or terminating in an awn.

An unimportant tribe, scarcely represented in India except by the monotypic *Thysanolaena*.

Tribe 5, Zoysieæ.—Spikelets hermaphrodite or some of them imperfect, not jointed to the rachis, solitary or clustered; flowering glume membranous, often smaller than the empty ones and transparent.

Zoysia procumbens and *Lappago procumbens* are common representatives of this small tribe.

Tribe 6, Andropogoneæ.—Spikelets in pairs at each node of the jointed rachis of the spike or of the branches of the panicle, or in triplets at the end of each branch; the

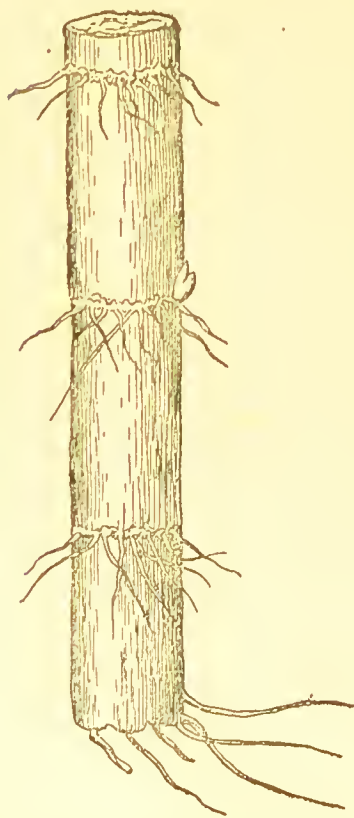
spikelets of each pair or triplet homogamous or heterogamous; flowering glume smaller than the empty ones by a line, and often awned.

A large tribe, chiefly tropical and subtropical. Among other genera it includes *Saccharum*, *Erianthus*, *Hemarthra*, *Ischaemum*, *Sorghum*, *Chrysopogon*.

S. cylindricum (Ulú) is a native of moist stiff pasture ground, particularly common over Bengal, where the fields are white with it when in flower after the first rains in April and May; it is generally used for thatching.

The fragrant roots of *Andropogon muricatus* (Khas-khas) are well known all over India; they are used for making tatties, covers for palkis, &c. It usually grows in low, moist, rich soil, on the banks of rivers.

Fig. 210.



Cutting of a Sugar-cane showing secondary roots developed from the nodes.

Saccharum officinarum (Uk) has solid culms from 6—12 feet high; extensively cultivated for its sugar-producing qualities; it flowers during the rains. *S. spontaneum* (Kash, kese) has culms from 5—15 feet high; it grows on the banks of rivers, railways, and other uncultivated land; it is used for making mats and for thatching houses.

SERIES B.—*Poaceæ*.

Pedicle continuous below the outer glumes; rachis often jointed above the persistent outer glumes, produced above the fertile flower, stalk-like or bearing empty glumes or imperfect flowers, or sometimes with one terminal flower as in the *Panicææ*, but then falling away with its glume from the persistent empty glumes.

Tribe 7, Phalarideæ.—Hermaphrodite flower 1; terminal glumes 6 (or 5 and a pale), 1-nerved or keeled.

A very small tribe, represented in the hills of Northern India by three or four species of *Hierogloë* and *Phalaris*.

Tribe 8, Agrostaceæ.—Spikelets 1-flowered; rachis produced or not beyond the flower in the form of a bristle.

This tribe is a rather large one, and is again divided into four subtribes. The species are mostly temperate and subtropical. *Sporobolus* is an Indian genus.

Tribe 9, Isachneæ.—Spikelets equally 2-flowered; glumes usually awnless; rachis not produced beyond the flowers. Example: *Isachne*.

Tribe 10, Aveneæ.—Spikelets two or more flowered, often paniced; flowering glumes almost always furnished with a dorsal, rarely terminal awn; rachis usually produced beyond the flowers.

Mostly grasses of temperate climates. Species of the typical genus, *Avena*, yield the valuable northern cereal oats.

Tribe 11, Chlorideæ.—Spikelets one or more flowered; sessile in two rows along the rachis of the unilateral spikes. *Elysinæ* and *Chloris* are representative genera.

Tribe 12, Festuceæ.—Spikelets two or more flowered, variously paniculate or rarely racemose; flowering glumes awned or awnless.

This tribe is numerous in genera and species; but they are chiefly inhabitants of temperate regions. *Exagrostis* is a large genus represented in tropical India.

Tribe 13, Hordeæ.—Spikelets one or more flowered; sessile in notches of the rachis of the simple spikes.

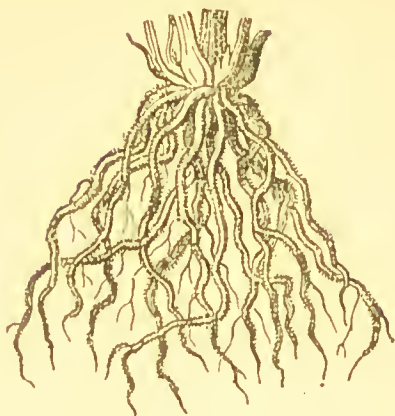
This tribe is neither numerous in genera nor species, yet it is one of the most important, as it embraces several of the most widely cultivated cereals, as Wheat (*Triticum*), Barley (*Hordeum*), and Rye (*Secale*).

Tribe 14, Bambuseæ.—Tall grasses, often woody, at least at the base; leaves flat; limb very often jointed to the sheath; spikelets one or more flowered; stamens 3—4 or more.

The bamboos are one of the most useful and important tribe of tropical and subtropical grasses.

The Gramineæ constitutes one of the largest natural orders, and includes probably from 3,000 to 4,000 species. They are universally distributed and have been culti-

Fig. 211.



Secondary roots as in most grasses.

Fig. 212.

Imbricated aestivation
of a grass (see
page 17).

vated from the remotest antiquity. Rice furnishes a larger proportion of food than any other single species.

Rye, barley, and oats are the hardier "cereal grains;" wheat is the chief grain of temperate and warm temperate climates. Rice and maize form the chief grains of the tropics: maize or Indian-corn, the largest cereal, is a plant of American origin.

GYMNOSPERMIA.

The second group of flowering plants (the gymnospermia) produce ovules on open carpellary leaves; the endosperm arises *before* fertilization, and *the contents of the pollen-grains are divided before the formation of the pollen tube*. In the peculiarities of their tissues and especially of their sexual reproduction, these plants occupy an intermediate position between Angiosperms and vascular Cryptogams. In the anatomical structure of the wood, Gymnosperms resemble Dicotyledons. They differ, however, in the layers of wood which are formed after the first year, being destitute of vessels and ducts and in the usual presence of bordered pits in the wood-tissue.

The Gymnosperms are divided into three orders, embracing plants of strikingly different habit, but closely allied in their morphological structure :—

ORDER I.—*Gnetaceæ*

Are shrubs or rarely small trees, usually with jointed stems, and destitute of the resin so characteristic of conifers. There are only three genera belonging to this order. *Ephedra*, which approach the *Casuarina* in habit, are confined to the Himalayas and other temperate regions. The species of *Gnetum* are climbing shrubs, with opposite glabrous leaves and monœcious flowers; the male flowers each consist of a single stamen, with a 2-celled anther or of 2 stamens having 1-celled anthers, the female of a naked ovule enclosed in an undivided perianth.

Welwitschia mirabilis, the only representative of the third genus, is a native of the desert regions of South-Western Africa; it is a most extraordinary dwarf-tree, seldom rising more than two feet above the sand in which it grows; it never has more than two leaves, but these are of immense size, and were believed to be the cotyledons; but it has

lately been ascertained that the cotyledons perish early and are succeeded by one pair of permanent leaves; the plant attains an age of at least a hundred years.

ORDER II.—*Coniferae*

Are trees or shrubs, with small, usually needle-shaped or scale-like leaves, rarely flat, as in *Podocarpus*. The flowers are always incomplete, and either monœcious or diœcious; the female flowers are of various forms, and are either solitary or united into cone-like inflorescences. The male flowers consist of a slender short or elongated axis on which the numerous staminal leaves are arranged.

The affinity of the *Coniferae* are with *Dicotyledons* by their habit of growth, although there is an essential difference in the internal structure of their organs. The pitted woody tissue with the absence of vessels and ducts serves to distinguish the wood of coniferous stems. The *Coniferae* may be roughly divided into three tribes—namely, the *Abietineæ*, the *Cupressineæ*, and the *Taxineæ*:

Tribe 1. Abietineæ.—Flowers usually monœcious; cones usually large, the scales becoming more or less woody; ovules two or more at the base of each scale, inverted. Trees with long needle-shaped leaves in fascicles of two, three or five according to the species (*Pinus longifolia*), or linear scattered leaves (*Cedrus deodara*), or small or large scale-like leaves (*Araucaria sequoia*).

Pinus longifolia is common in the Himalayas at elevations of 5,000 to 6,000 feet. The wood is light, and being full of resinous matter is frequently employed in the hills for making torches.

P. deodara (Debpáru) is also a Himalayan tree; the wood is durable and is used in the construction of Himalayan houses. Both these trees yield a large quantity of turpentine and resin.

Tribe 2. Cupressineæ.—Female flowers in small cones or strobiles consisting of a few scales and no bracts, usually thickening and forming a globular or ovoid fruit; ovules and seeds erect, one or more at the base of each scale. Trees or shrubs with small spreading awl-shaped, or scale-like closely imbricated leaves. Examples: *Juniperus communis*, *Thuja orientalis*.

Tribe 3. Taxineæ.—Fertile flowers, solitary, ripening into a fleshy fruit; ovule erect; leaves linear, scattered (*Taxus*); leaves flat, rather broad (*Podocarpus*). In this genus, the last trace of resemblance in habit to the flowers of Angiosperms ceases, only a few ovules being produced on a naked inflorescence; the flowering shoots are developed from the axils of foliage leaves.

In Hooker and Bentham's *Genera Plantarum* the order is divided into six tribes, based upon modifications of the inflorescence and the position of the ovules.

ORDER III.—*Cycadeæ*

Are tropical or subtropical dioecious trees or shrubs, with simple or branched stems, resembling palms and tree ferns in their habit; the flowers are arranged in terminal cones at the apex of the stem in the centre of the crown of leaves, or they are lateral.

In *Cycas* the female cone is truly terminal, consisting of a rosette of scales or leaves similar to the ordinary ones, though smaller and ovuliferous only in their lower parts, and further growth takes place through its axis. There is, in fact, an alternation of ordinary leaves and ovuliferous leaves on the same axis. In all the other genera, the cones are subterminal and deciduous. The ovules are borne on flat or peltate scales, either beneath, or at the base, or on the margins. The *ovule* contains several embryos, but only one

Fig. 213.



Cycas revoluta (after Oliver).

is developed; the seeds have a hard or succulent testa. The 1-celled anthers or polliniferous cells cover the under surface of the male cone-scales. The distribution of the reproductive organs over the leaflike carpels together with the occasional circinate veneration of the leaf-segments connect this order with the ferns.

Cycas revoluta is very common in gardens about

Calcutta. It has somewhat the appearance of a tree fern ; it lives to a considerable age. *C. circinalis* is common in gardens near the sea-coast of the southern provinces of Malabar ; a kind of flour is prepared from the fruit after it has been dried some time. *C. rumphii* is a peculiar branched species ; it is occasionally cultivated in gardens. There are some fine specimens of this plant in the Botanical Gardens, Shibpur. The stem is marked with scars of two kinds—those of the true leaves and those of the floral leaves.

Zamia longifolia and *Z. horrida* are also sometimes cultivated.

CRYPTOGAMIA.

The second division of the vegetable kingdom—Cryptogamia (see abstract, page 80*g*)—includes plants destitute of flowers, containing anthers and ovules. In Phanerogams, two sexual cells, dissimilar in form, size, and other respects, perform the process of fertilization; one of the two sexual cells is the *male*, *sperm*, or *pollen-cell*, the other the *female*, *germ-cell*, or *germinal vesicle*. From the connection of these dissimilar cells, a structure arises which can no longer be considered a part of the connected conformation of the parent plant. These plant structures form a *generation*.

In most Thallophytes, and in all Muscineæ and vascular Cryptogams, the generations which proceed from one another are dissimilar, having dissimilar habits of life and conformation. For example, a generation of the kind *A* will produce one of the kind *B*, and this again one of the kind *A*. "The whole process of development which passes through the successive dissimilar generations, and finally returns again to the first form, is called *alternation of generations*." (A more comprehensive conception of the alteration of generation makes it applicable to flowering plants; but in these the first generation does not exist as an independent growing plant. The endosperm of flowering plants has been regarded as analogous to the prothallium, the embryo-sac to the macrospore, and the pollen-grain to the microspore of certain Cryptogams. But the endosperm is often wanting, and alternation of generation has almost disappeared.)

"It is only in some Algæ and Fungi that all successive generations are similar and produce similar reproductive

cells," as in Nostocaceæ, etc., where asexual generations follow one another without intermission. In Spirogyra, etc., an uninterrupted series of sexual generations succeed one another.

The usual case among Algæ and Fungi, and the universal one among Museinæ (Mosses and Liverworts) and vascular Cryptogams (Ferns, Horse-tails, and Stag-mosses), is, however, for sexual and asexual generations to alternate regularly. When the reproductive cells are asexual, that is, developed independently of any foreign aid, the generation from which they are derived is called an *asexual generation*. The asexual reproductive cells usually become detached from the mother plant, and are dispersed (hence called *spores*), in order to produce the new generation at a distance from it. When the reproductive cells are sexually developed, the generation to which they owe their origin is called a *sexual generation*. One of the two sexual cells, the germ or female cell, generally continues to lie in a special organ of the mother plant (the *oogonium*, *archegonium*), and there waits fertilization by the other sexual or male cell (*spermatozoid*, *antherozoid*).

The classification of Cryptogams proposed in the fourth edition of Sachs' *Lehrbuch der Botanik* is here adopted; it rests on such a sound scientific foundation that it must ultimately come into general use in its main features. The whole range of Cryptogams he divides into three groups: 1st, Vascular Cryptogams; 2nd, Museinæ; and 3rd, Thalphytes.

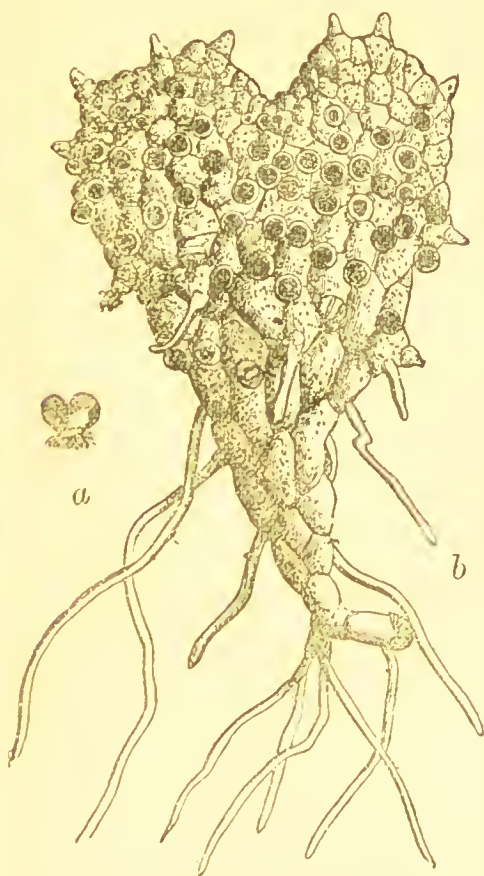
GROUP I.—VASCULAR CRYPTOGRAMS.

In vascular Cryptogams, the *sexual generation* which proceeds from the spores is a small body of the simplest kind, without any considerable differentiation of tissues. It appears externally as a mere precursor of further development; hence the name *prothallium* (see Fig. 166) has been given to it. In Filicinæ and Equisetaceæ, the prothallium carries on an independent existence resembling the thallus of the lower Hepaticæ (liverworts). In the Dichotomæ (Selaginella, Club-mosses) it becomes simpler, and its morphological differentiation less pronounced. In Ferns and Equisetaceæ, the prothallia continue to grow

for a considerable time, and contain a large amount of chlorophyll and form numerous root-hairs.

When mature, the prothallia produce the *archegonia* (a special organ of the mother plant, in which the germ-cells

Fig. 214.



Prothallium (sexual generation) of a fern.

- a. The prothallium, natural size, to be found on damp walls, etc.
b. The same prothallium magnified.

are formed), and *antheridia* (cells, or masses of cells, which produce the male reproductive bodies), usually in considerable numbers; in Equisetaceæ these prothallia are usually dioecious, the male prothallia being smaller than the female; in ferns, monoecious, although they both proceed from similar spores.

In the division Rhizocarpeæ and Ligulatæ, there are two kinds of spores—*macrospores* (female) and *microspores* (male). The macrospores develop a female prothallium, which remains within the spore, or is only partially protruded, and which produce exclusively archegonia, or sometimes only a single one. In Ligulatæ, the prothallium is developed in the spore itself, filling it up with a mass

of tissue, the archegonia becoming exposed only by the splitting of the cell-wall of the spore. This process is similar to what takes place in the ovules of gymnosperms, where, before the pollen-grains fall on the micropyle, the embryo-sac becomes filled up by free cell formation with

delicate cellular tissue (the endosperm), in which are formed the *corpuseula* or secondary embryo-sacs, and which are very much like the archegonia in the internal prothallium structure of Selaginella. The microspores produce a rudimentary male prothallium, which remains within or attached to the spore, analogous to what is seen in the pollen-grains of Gymnospermia, which, in like manner, produce a rudimentary prothallus.

The *archegonia* of vascular Cryptogams are like those of the Muscinæ, consisting of a cup-shaped mass of tissue enclosing the *oosphere* (female-cell) and of a restricted portion, the neck. The flask-shaped archegonia are hollow receptacles formed in the thick part of the prothallium, and have a narrow neck-like passage through which the antherozoids reach the oosphere (female-cell). In vascular Cryptogams, however, the tissue of the ventral part is formed from the prothallium itself. The antherozoids or spermatozoids, as they are sometimes called, are similar to those of the Muscinæ spirally coiled threads, usually with a number of fine cilia on the anterior coils. *The asexual generation is that in which the plants are commonly seen and known, and during which they attain the highest degree of development; in the vegetative structure, they arise from the oospore (fertilized oosphere) in the archegonium; they soon become independent plants, which free themselves at a very early period from the prothallium, and obtain their own nourishment. It is this asexual generation which is called in ordinary language the Fern, Equisetum, etc.* Roots are usually present except in *Salvinia*, *Psilotum*, and some species of *Hymenophyllum*, and they always remain nearly uniform in size. The leaves are not so varied in their forms as in Phanerogams; they are either simple, segmented or variously branched. The differentiation of the tissues into epidermis, fundamental tissues, and fibro-vascular bundles are always clearly distinguishable. Vascular Cryptogams form a group connected with one another by very obvious bonds of relationship, but may be divided into three tolerably well marked classes: (1) *Filicineæ*; (2) *Equisetaceæ*; and (3) *Dicotylomiti*:

ABSTRACT OF VASCULAR CRYPTOGRAMIC ORDERS.

VASCULAR CRYPTOGRAMS.	{ Filicineæ	... {	Stipulatæ	... {	Ophioglossaceæ. Ex.: Adder's Tongue.
				... {	Marattiaceæ. Ex.: Marattia.
	{ Filices	... {			Polypodiaceæ. Ex.: Maiden-hair, etc.
					Cyatheaceæ. Ex.: Tree Ferns.
					Osmundaceæ. Ex.: Royal Fern.
					Schizæceæ. Ex.: Twining Fern, Lygodium.
	{ Rhizocarpeæ	... {			Gleicheniaceæ. Ex.: Gleichenia.
					Hymenophyllaceæ. Ex.: Film Ferns.
	Equisetaceæ	...			Marsileaceæ. Ex.: Pepper-worts.
					Salvineaceæ. Ex.: Water Ferns.
	{ Dichotomi	... {			Equisetaceæ. Ex.: Horse-tails.
	{ Ligulatæ	... {			Selaginellæ. Ex.: Selaginella.
					Isoetæ. Ex.: Quill-wort.
	{ Lycopodiaceæ	... {			Lycopodiæ. Ex.: Stag's horn Moss.
					Psilotæ. Ex.: Psilotum.

CLASS I.—FILICINEÆ.

The second or asexual generation are plants with large usually divided leaves, bearing *sporangia* (capsules containing spores) (see Fig. 167), collected in *sori* (groups of sporangia), usually on the under surface of the leaf. The Filicineæ are divided into—(1) *Stipulatæ*; (2) *Filices*; (3) *Rhizocarpeæ*.

Fig. 215.



A sporangium of a Fern (magnified).

Division I.—STIPULATÆ.

These plants, hitherto included among ferns, must be separated from them in consequence of the entirely different mode in which their sporangia are formed; they agree with the sporangia of all vascular Cryptogams, in the one point of belonging to the leaves. The sporangia in the Stipulatæ are not, however, products of single epidermal cells, as in Ferns and Rhizocarps, but their origin more resembles that of the pollen-sac of the anthers of many angiosperms. The stipulate structure occurring in these plants is entirely foreign to ferns. The second or asexual generation is usually unbranched, the leaves stipulate, and the sporangia are produced from the mesophyll of the leaf, and of one kind only. The Stipulatæ are divided into two orders—*Ophioglossaceæ* and *Marattiaceæ*.

Order 1.—*Ophioglossaceæ*.

The prothallium is developed underground and is destitute of chlorophyll. The leaves are not circinnate in veneration; and the sporangia dehisce by two valves opening down the side nearly to the base; they have no ring or annulus.

Order 2.—*Marattiaceæ*.

The leaves are circinnate in veneration; the sporangia open by pores or by a slit down one side of the capsule; they are without a ring, and are usually jointed together in concrete masses (synangia).

Division II.—FILICES.

The sexual generation or prothallium arising from the spores of the plants of this group, is a thalloid structure containing chlorophyll, and obtaining its nourishment independently; it produces simple root-hairs (rhizoids), and finally antheridia and archegonia; the prothallia of Polypodiaceæ are bright green organisms of a scale-like appearance; they grow abundantly on old walls and low ground, in damp and shady situations; they are found most abun-

dantly at the beginning of the rainy season. The prothallia

Fig. 216.



Pinnate leaf (frond) of a Fern.

are monœcious, though, as in *Osmunda*, they show a tendency to be diœcious.

The second or asexual generation or fern as it is popularly termed, is erect and unbranched, or prostrate and slightly branched; the mature fern is in some *Hymenophyllaceæ*, a small delicate plant, not much exceeding in dimensions the larger *Muscineæ*; in other sections, the fully grown plants attain the size of considerable shrubs; some species assume even a palm-like habit, and are called tree ferns.

The leaves (commonly known as *fronds*) are not stipulate, they are usually characterized by a circinnate veneration, and they only unroll in the last stage of their growth. The form of the leaves are among the most perfect in the whole vegetable kingdom, the laminæ are usually deeply lobed, branched, or pinnate. In *Lygodium* the leaf-stalk or rachis

resembles a twinning stem, growing for a long period, the pinnæ presenting the appearance of leaves.

The sporangia (capsules) arise from single epidermal cells, and are usually stalked unilocular capsules. A ring of cells is generally developed on the capsule in a peculiar manner, and is termed the *annulus* (see Fig. 167); by its contraction when it dries up, the capsule bursts. Sometimes, instead of the annulus, a terminal or lateral group of cells of the wall of the capsule is developed in a similar manner. The sporangia are generally combined into groups (sori), each group being termed a *sorus* (see Fig. 217). The sorus contains either a small definite number, or a large indefinite number, of sporangia. The whole sorus is generally covered by an outgrowth of the epidermis, the *indusium* or involucre (see Fig. 217). In some cases the sori are uniformly distributed over the

Fig. 217.



Portion of a frond
with two sori covered
by indusia.

whole of the lamina: in others they are connected with definite portions of it. The spores are of one kind only; they do not usually germinate till a considerable time after dissemination.

The systematic *classification* of ferns is based artificially on the form of the mature sporangia for the orders, and of the form and arrangement of the sori for the genera. The Filices may be divided into six orders: (1) *Polypodiaceæ*; (2) *Cyathecaceæ*; (3) *Osmundaceæ*; (4) *Schizaceæ*; (5) *Gleicheniaceæ*; and (6) *Hymenophyllaceæ* (see Hooker and Baker's *Synopsis Filicum*):—

Order 1.—*Polypodiaceæ*.

Sori dorsal or marginal, of many capsules, usually pedicellate; annulus vertical and incomplete; dehiscence transverse.

Order 2.—*Cyathecaceæ*.

The annulus is complete, oblique; dehiscence transverse; sporangia sessile. Mostly tree ferns.

Order 3.—*Osmundaceæ*.

Sporangia shortly stalked; dehiscence longitudinal, 2-valved, opening across the apex, furnished with a short horizontal ring.

Order 4.—*Schizæaceæ*.

The annulus is in the form of a cap; the dehiscence is longitudinal; capsule 2-valved, opening down the side. In *Lygodium*, the climbing leaf-stalk ends in a lamina, which is not circinnate.

Order 5.—*Gleicheniaceæ*.

The sori are dorsal; sporangia sessile, arranged in threes, or fours, with a complete transverse annulus; dehiscence longitudinal; involucre none.

Order 6.—*Hymenophyllaceæ*

Are small, often epiphytal ferns. The sporangia are formed on a prolongation of the vein, beyond the margin of the leaf; the annulus is horizontal or oblique; dehiscence longitudinal.

Division III.—RHIZOCARPEÆ.

The sexual generation of *Rhizocarpeæ* is developed from spores of two different kinds,—the smaller, the microspores (male), and the larger (which exceed the smaller several hundred times in size), the macrospores (female). The sporangia are formed in hollow capsular stalked receptacles, closed on all sides, usually termed sporocarps.

The *Rhizocarpeæ* is divided into two orders:

Order 1.—*Marsileaceæ*

Are perennial plants, ereeping in mud; microspores and macrospores in the same sporocarp. Example: *Marsilea quadrifolia*.

Order 2.—*Salvineaceæ*

Are annual plants floating on water; microspores and macrospores in distinct sporocarps. Example: Water Ferns.

CLASS II.—EQUISETACEÆ.

The second or asexual generation are herbaceous plants, with fistular jointed stems (horse-tails), see Fig. 218. In the sexual generation the prothallia are generally diœcious; the male prothallia are small, the female are much larger (as much as half an inch).

All existing forms are so nearly related to one another that they may be included in a single genus *Equisetum*; even the Equisetaeae of earlier geological periods, the *Culamities*, show in the little that is still discernible of their organization, the closest agreement with existing forms.

CLASS III.—DICHOTOMI.

The second or asexual generation is usually repeatedly dichotomously branched, with very small 1-nerved leaves; the sporangia are solitary. The Dichotomeae may be divided into two divisions: *Ligulatæ* and *Lycopodiaceæ*.

Division I.—LIGULATÆ.

The leaves are furnished with a ligule near the base; the spores are of two kinds. The prothallia are small, and are never independent of the spores.

Order 1.—*Selaginelleæ*.

The leaves are small, scale-like, are placed in four rows, and are of different sizes; the lateral rows consisting of larger, the upper and under of smaller leaves.

Order 2.—*Isoeteæ*

Are aquatic plants, with a simple cylindrical but only slightly developed stem, with long grass-like leaves.

Division II.—LYCOPODIACEÆ.

The Lycopodiaceæ possess only one kind of spore; the leaves are simple sessile, and with a single central vein; they are all of the same size, and are arranged spirally on the stem.

Order 1.—*Lycopodiææ*

Are plants with procumbent stems, hard and woody. Several species of the Lycopods are commonly known as stag's horn moss, or club moss.

Order 2.—*Psilotæ*

Are plants with long, slender, many forked stems, and very small rudimentary leaves; true roots are altogether wanting; the sporangia are trilocular.

DETAILS OF VASCULAR CRYPTOGRAMIC ORDERS.

Order I.—*Ophioglossaceæ*.

In the sexual generation the *Ophioglossaceæ* is a monœcious prothallium developed underground; which produces a number of antheridia and archegonia; the antheridia are cavities in the tissue of the prothallium; the antherozoids are similar in form but larger than those of the *Polypodiaceæ*. The archegonia are developed in a similar manner to those of other vascular Cryptogams.

Fig. 218.

*Ophioglossum*.

The asexual generation bears the sporangia, which are essentially different from those of ferns; they agree with the sporangia of all vascular Cryptogams in the one point of belonging to the leaves; they are not, however, the product of single epidermal cells, as in Ferns and Rhizocarps. The sorus is an entire lobe of a leaf, the inner tissue of which produces the mother cells of the sporangia, thus resembling the pollen-sac of the anthers of many angiosperms. *Ophioglossum reticulatum* (Bak, Ekteera) is a native of cool, shady places, where it

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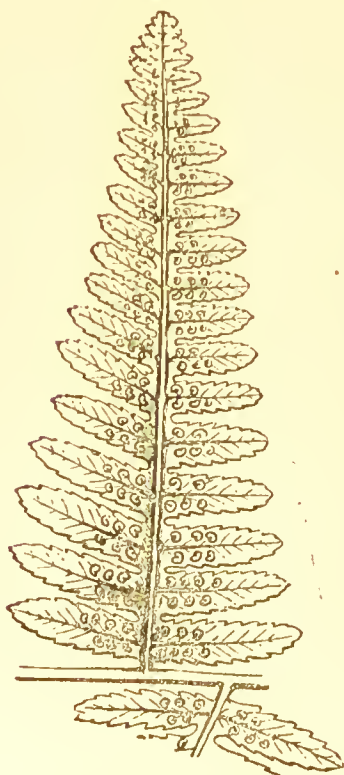
appears during the rainy season. *O. vulgatum*, L., is the common adder's tongue. Other genera are : *Botrychium*, Swartz ; and *Helminthostachys*, Kaulf.

Order II.—*Marattiaceæ*.

In this order the sori are placed singly on lateral veins of the pinnae, to which they are attached by a narrow ridge shaped base; they resemble the *Ophioglossaceæ* in the origin of their spores, and by their stipular structure which is entirely foreign to true ferns. The commonest genera are : *Marattia*, Sm. (which is a well-marked genus, extending all round the world within the tropics); and *Angiopteris*, Hoffm.

Order III.—*Polypodiaceæ*

Fig. 219.



Are ferns with stalked sporangia, having a vertical incomplete annulus with transverse dehiscence. This order may be divided into ten sub-orders, which may be grouped into two divisions; the first (*Involucratae*) containing plants having an indusium, the second (*Exinvolucratae*) comprising those which have none (see Hooker's and Baker's *Synopsis Filicum*):

A portion of the leaf (frond) of a fern showing the spore cases in which the spores are formed.

A.—INVOLUCRATÆ.

1. *Aspleniæ*. The sori are unilateral on the course of the veins.
2. *Aspidiæ*. Indusium uniform or peltate.
3. *Davalliæ*. The sori are terminal on a vein, or at a fork or are placed on an intra-marginal anastomosing bend of the veins.
4. *Lindsææ*. Indusium bursts along its outer margin, attached interiorly.
5. *Pteridæ*. Sori usually linear marginal; indusium bursting along its outward margin, attached exteriorly.
6. *Blechnæ*. Sori linear situated between the mid-rib and margins of the leaflets.
7. *Dicksoniæ*. Indusium cup-shaped, reflexed.

B.—EXINVOLUCRATÆ.

1. *Acrosticheæ*. Fronds wholly fertile.
2. *Polypodiæ*. Sori usually globose.
10. *Grammitidæ*. Sori linear or oblong.

1.—The *Aspleniæ* include the genera *Asplenium*, L.; *Allantodia*, R. Br.; and *Actiniopteres*, Link.

2.—*Aspidiæ* contain the genera *Aspidium*, a cosmopolitan genus; *Nephrodium*, also cosmopolitan; *Nephrolepis*; *Oleandra*, a small genus almost restricted to the tropics, distinguished from *Nephrodium* mainly by habit, having widely creeping scandent shoots, jointed stems, and entire lanceolate elliptical fronds.

3.—*Davalliæ* include the genera *Davallia*, *Cystopteris*, a genus allied to *Woodsia*.

4.—*Lindsææ* contain only a single genus *Lindsæa*.

5.—*Pteridæ* contain the genera *Adiantum* (maiden-hair ferns), most of the species of which are recognizable from all other ferns except the typical *Lindsæa* by the texture and one-sidedness of their segments; *Cheilanthes*, in which the fronds are under a foot long, often under six inches. It is very difficult to draw the line between *Cheilanthes* and *Nothochlæna*,

Fig. 220.

Leaflet of an *Adiantum*.

which is the corresponding non-innervate genus. *Onychium*, *Cryptogramme*, *Pellaea*, *Pteris*, a large cosmopolitan genus; *Ceratopteris* and *Lomaria*, a considerable genus closely connected with *Blechnum*.

6.—*Blechnæ* contain the genera *Blechnum*, *Woodsia*, and *Doodia*.

7.—*Dicksoniaceæ* contain the genera *Onoclea*, large herbaceous ferns; *Woodsia*, small herbaceous much tufted ferns; *Sphaeropteris*, and *Dicksonia*.

8.—*Acrosticheæ*, containing the single genus *Acrostichum*, L., are readily distinguished by the back of the fronds being almost or entirely covered with spore-cases.

9.—*Polypodiææ*, including also only one genus *Polypodium*, which contain a larger number of species than any other genus.

10.—*Grammitideæ* include the genera *Nothochlæra*, R. Br.; *Gymnogramme* Desv., *Bramea*, K., a genus of subarborescent ferns; *Meniseium*, Schreb.; *Antrophyum*, Kauf., ferns with simple fronds of firm but fleshy texture; *Vitaria*, ferns having grass-like fronds of subcoriaceous texture; *Drymoglossum*, Prsl.; and *Hemionitis*, L.

Order IV.—*Cyatheaceæ*.

The *Cyatheaceæ* are mostly tree ferns. The sori more or less elevated on a common receptacle are dorsal, globose; sporangia sessile or stalked, with an oblique annulus; dehiscence transverse; involucre scale-like, or cup-shaped, or absent in *Alsophila*. Common genera are: *Cyathea*, Sm.; *Alsophila*, R. Br.; *Diaculpe*, Bl.; *Matonia*, R. Br. (not arborescent); and *Hemitelia*. The *Alsophila* are arborescent ferns, with the general habit of *Cyathea* and *Hemitelia*, but destitute of involucre. *Alsophila latebrosa*, H. K., is common almost throughout India proper and the Malay Islands, and is the common kind of tree fern seen round Darjiling.

Order V.—*Osmundaceæ*.

The *Osmundaceæ* are striking ferns, clearly marked by habit. The numerous shortly-stalked sporangia are arranged in dense sori on the back of the frond or in a spike or panicle, due to the non-development of the parenchymatous tissue between the veins; the annulus is horizontal and incomplete; the dehiscence is longitudinal. Other genus, *Todea*, Willd.

Order VI.—*Schizaceææ*.

The sporangia are ovoid or pear-shaped; sessile or shortly-stalked, opening down one side; the annulus is complete

and circular, and is in the form of a cap, on the summit; the dehiscence is longitudinal. *Lygodium* is a small widely diffused genus, well characterized by its scandent twining stem. The primary branches end in a lamina which is not circinnate. *Lygodium scandens*, Lin., is common in most parts of India; the sporangia appear in the rains and cold season; the compound fronds are like slender climbing stems, bearing small fronds, and are of indefinite growth. *Lygodium flexuosum*, Sw. (Bhut-raj), is a perennial scandent plant; the fronds are compoundly pinnate; the ultimate segments are long and narrow, having sporangia on both sides.

Schizæa, Smith, is a small widely-diffused genus, very distinct in habit. Other genus, *Anemia*, Sw.

Order VII.—*Gleicheniaceæ*.

The sori are dorsal, without indusium; sporangia sessile, usually two to ten in each sorus; the annulus is complete, transverse or oblique; dehiscence longitudinal.

Order VIII.—*Hymenophyllaceæ*.

This order contains the lowest forms of ferns, most nearly allied to the mosses; they are small, often epiphytic; the sporangia have an oblique or transverse complete annulus, and therefore burst with a longitudinal slit; they are formed on a prolongation of the fertile vein projecting beyond the margin of the leaf, which is surrounded by a cup-shaped indusium. The genus *Hymenophyllum*, Smith, contains small, sometimes very minute ferns, frequently found growing on trunks of trees and damp rocks; the fronds are of delicate texture, often of an olive-green colour. The *Trichomanes*, L., agree with the last in habit of growth and delicacy of texture; the shape of the involucre is characteristic.

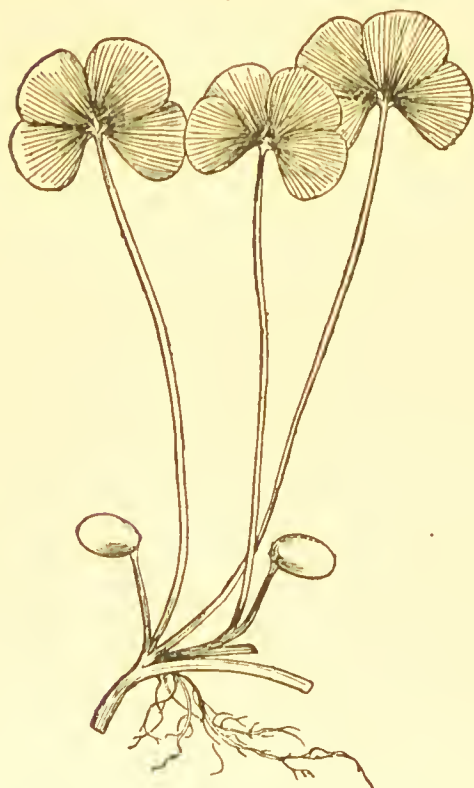
Order IX.—*Marsiliaceæ*.

In the asexual generation, these plants are perennial, creeping in mud; the microsporangia and macrosporangia are contained in the same sporocarp. The sporocarp has somewhat the form of a bean, the stalk running up one of its edges; the interior of the sporocarp is divided into

compartments, each containing a sorus, the placenta of which extends on its external face from the dorsal to the ventral edge of the sporocarp and projects inwards in the form of a ridge along the centre; the placenta bears a row of macrosporangia, and on either side of this, a row of microsporangia.

The sporangia must be considered as metamorphosed

Fig. 221.



Marsilea quadrifolia, with two sporocarps.

leaves with united pinnae, and bearing the sporangia on their upper sides in a definite relation to the course of the veins, in the same manner as among the ferns.

Beneath the epidermis of the wall of the sporocarp, which is at first very hairy, lie two or three layers of thickened and lignified cells, which form a very hard sporocarp-wall, scarcely permeable by water.

Marsilea quadrifolia, Roxb. (Sūseshāk), is very common on the borders of tanks and marshy places; the leaves have long petioles, with four leaflets at the summit. The leaflets are broad

obcordate, entire, resembling the leaflets of *Oxalis* or *Trifolium*.

Order X.—*Salviniaceae*

Are annual plants floating in water; the microsporangia and the macrosporangia are formed in different sporocarps, which are the metamorphosed teeth of the submerged leaves. A resemblance can thus be traced between the sporocarp of *Salvinia* and the indusiate sorus of *Hymenophyllaceae*. In *Salvinia* the wall of the sporocarp is thin and delicate.

Salvinia imbricata, Roxb. (Pana), is a floating ramous plant, trapeziform; the leaves are sessile, alternate, and imbricated; the sporocarps are situated between the roots, on the underside of the plant, and are covered by imbricated seales. *S. cucullata*, Roxb., is a small floating ramous plant; the leaves are opposite subsessile, eowl-shaped. *S. verticillata*, Roxb., is a floating plant; the leaves are opposite petioled, oval, flat; the sporocarps are formed on the underside of the plant between the insertion of the leaves, surrounded with long hairy triehomes. In *S. hispida*, the leaves are orbicular, cordate. *Azolla pinnata*, R. Br., is a pinnately branched plant, with minute leaves; it differs from the *Salvinia* in having no true roots. All the *Salvinias* are common in Bengal during the rains.

Order XI.—*Equisetaceæ*.

In the asexual generation, the *Equisetaceæ* consist of herbaceous plants (horse-tails) with jointed rhizomes, and fistular jointed stems, with sheaths formed by the coalescence of the leaves at their base; the stems are verticillately branched at the joints; their vegetative organs have a resemblance to the dicotyledonous order *Casuarinæ*.

The fibro-vaseular bundles are arranged in a circle, between the central and cortical air-cavities; these bundles ascend in a vertical direction and parallel to one another through the internodes; a quantity of silica is deposited in the stems, and especially in the epidermis. In their mode of reproduction, the *Equisetaceæ* closely resemble ferns.

The sporangia of *Equisetaceæ* are outgrowths of peculiarly metamorphosed leaves, and are generally formed in numerous whorls, at the summit of ordinary shoots, or of those specially destined for this purpose; the spores have three coats,—the first formed coat is capable of swelling; it splits subsequently into two spiral bands forming the so-called *elaters*; a second and third coat soon afterwards make their appearance within it: all three lie at first closely one upon another like successive layers of a single coat; but when the spore is placed in water, the outer one swells up strongly and becomes detached from the others, and at the same time its division into *elaters* is first indicated, which by their hygroscopic properties assist in

the dissemination of the spores. The spores are highly organized, containing a nucleus and chlorophyll granules. The *sexual generation* arises from the spores, which when sown in water, or on damp soil, show the preparatory phases of germination after only a few hours, and consist of *independently existing* usually *diacocious prothallia*; upon the prothallia are produced the antheridia and archegonia; in the antheridia are developed a number of eventually motile antherozoids; in the archegonia, a single central cell, containing an oosphere, which after fertilization develops into a young plant.

The Equisetaceæ at present existing consist of a single

Fig. 222.



Portion of a stem of an
Equisetum with sporangia.

genus *Equisetum*. *Equisetum debile*, Roxb., is the commonest species of *Equisetum* in India; it grows abundantly in the plains and in the Himalayas. *E. diffusum*, Don., is a plant common in Northern India; the stem and branches are slender; the latter, from three to five inches long; the whole plant is about eighteen inches high. *E. elongatum*, Willd., is a taller plant than *E. diffusum*; the branches also are not so long; it grows in North-western India. *E. arvense*, L., is from six to eight inches high; the axis is very succulent. In *E. variegatum*, Sehl., the nodes are of a bluish colour. *E. limosum*, L., the smooth naked horse-tail is also to be found. *Calamites* and other plants referable to this order occur in the Gondvâna, and carboniferous formations of India and Europe.

Order XII.—*Selaginellæ*.

The asexual generation are terrestrial plants, bearing small heart-shaped leaves arranged in four nearly vertical rows, and are of *two sizes*; the repeatedly dichotomizing branches are densely covered with them. (See modes of branching, page 15.) The sporangia are shortly stalked,

roundish capsules, arising from the base of the leaf or from the stem itself.

The Selaginellæ are cultivated for the elegance of their foliage. *Selaginella verticillata* is a plant somewhat resembling the stag-horn moss in appearance, but of a more delicate green colour. *Selaginella bi-color* is a trailing plant, very common in the gardens about Calcutta; the leaves, particularly during the rains, have a peculiar metallie lustre, in which dark blue, bronze, orange, and pale green are beautifully blended. *S. caudata*, Spring, is a large handsome plant. *S. Jacque montis*, Spring, is a small plant common in the Himalayas; many other species are to be found in the Himalayas and Burmah.

Order XIII.—*Isoetecæ*

Are in the asexual generation, aquatic plants, with long grass-like leaves; the stem is distinguished by its extraordinary small growth in length; the leaves have broad bases of insertion, and do not leave between them any surface of the stem bare. The sporangia do not dehisce, but the spores escape by the decay of the wall.

Isoetes capsularis, Roxb., grows in deep standing water with *Valisneria spiralis*; the leaves are delicate, from two to three feet in length, only about a quarter of an inch broad, and are slightly serrated near the apex. The sporangia are produced from the leaves and are heart-shaped.

Order XIV.—*Lycopodiæ*

Are terrestrial plants with small usually closely imbricated leaves, of *one size*; the sporangia are reniform and arise in the axils, or at the base of the upper surface of the leaves, and are larger than those of the ferns; they contain tetrahedral spores of one kind only; they split when mature into two valves at the apex, or on the anterior surface.

The prothallia are developed underground and are monœcious. The genus *Lycopodium* includes a very large number of species common in India, principally in the Himalayas and mountains of Southern India. *L. clavatum*, L., is one of the commonest species. Thirteen Indian species

are represented in the Herbarium at the Royal Botanical Garden, Shibpur.

The *Lepidodendra* are fossil Lycopods described by Hugh Miller as "great plants of the club-moss type, that rose from 50 to 70 feet in height."

Order XV.—*Psilotaceæ*

Are plants with long slender, many forked stems, and very small rudimentary leaves; true roots are altogether wanting. Example: *Psilotum triquetrum*, Swartz.

GROUP II.—MUSCINEÆ.

The mosses and liverworts, which are comprised under the term Muscineæ, resemble the vascular Cryptogams in the fact that their life history consists of a sharply defined alternation of generation, a sexual (the moss) and an asexual. This last structure, when observed externally, appears simply as a fruit; it is hence called indifferently fruit, or sporogonium, and is destined for the production of asexual spores.

When the asexually produced spore germinates, it gives rise in most of the Hepaticæ immediately to the sexual generation; in all the mosses and a few Hepaticæ a coniferoid thallus is first formed called a *protonema*, from which

Fig. 223.



A moss (*Hypnum*) showing the leafy portion (sexual generation) and fruit-like structure (asexual generation) in which the spores are formed.

the sexual generation develops. The sexual generation, unlike that in vascular Cryptogams, is largely developed, and forms the plant commonly known as a *moss* or *liverwort*. The sexual generation is either a flat leafless thallus, as in most liverworts, or a slender leafy stem, often much branched, as in most mosses. In most cases, the thallus or the apex of the leafy stem continues to grow, while the older parts die off; in this manner, the branches finally become independent plants,

and this, as well as multiplication by gemmæ, &c., serves not only to increase the number of individuals, but is also the immediate cause of the social mode of growth of these plants. In this manner many mosses, such as *Sphagnum*, *Hypnum*, &c., form dense masses extending over considerable areas.

The sexual organs of the Muscineæ are *antheridia* (male) and *archegonia* (female). The mature antheridium is a body with a longer or shorter stalk of a spherical, ellipsoidal, or club-shaped form, within which the *antherozoids* are formed, which are spirally coiled threads, thicker at the posterior, and tapering to a fine point at the anterior end, at which are placed two long fine cilia, the vibrations of which cause motion. The female organs (the archegonia) are, when in a condition capable of being fertilized, serai-shaped bodies bulging from a narrow base and prolonged into a long neck; they contain within the cavity the *oosphere* or female cell. The antheridia and archegonia are usually produced in great numbers in close proximity. In the thalloid forms of the Hepaticæ, they are generally enveloped by later outgrowths of the thallus. In mosses and some Hepaticæ, several archegonia are commonly surrounded by an envelope formed of leaves, which is termed the *perichæcium*. In the mosses the antheridia are frequently collected in inflorescence-like structures either with the archegonia or in a monœcious or dioecious condition.

The asexual generation or sporogonium arises in the archegonium from the fertilized oosphere. It forms a cellular body which causes the expansion of the original wall of the archegonium. After a time the wall gives way in the mosses by a circumscissile dehiscence, so that the upper part is carried upwards, ultimately becoming the *calyptra* of the sporogonium. Its behaviour supplies distinctive characters for the larger groups. In the lower Hepaticæ the sporogonium remains always enclosed in the calyptra; in the higher Hepaticæ, it protrudes only after the ripening of the spores. As the sporogonium grows, it becomes differentiated into a slender stalk or *seta* and a *capsule* or *urn* or *theca* in which the spores arise.

The mode of development of the spores of Muscineæ

agrees in the main points with that of the pollen of Phanerogamia; the layers of the tissue, which produce the spores, after multiplying to a certain extent, form free cells from the whole contents of each cell; each of these cells become divided into four, and each of these four new cells produces a single free cell from its whole contents. These last formed cells, set free by the solution of the enclosing membrane, are the spore cells, which when ripe are often marked with points or reticulations like pollen-grains. The ripe spores have a thin cuticle (the exospore) provided with small excreseences which is ruptured on germination by the inner layer of the cell-wall (endospore). The differentiation of the tissue of Muscineæ is not so considerable as in vascular Cryptogams; fibro-vascular bundles are not formed, only in the stem, and leaf-veins of the more perfect mosses, is an axial bundle of elongated cells differentiated, which may be considered as a slight indication of the fibro-vascular system.

The Muscineæ are divided into two classes: 1st, Musei (mosses), and 2nd, Hepaticæ (liverworts).

ABSTRACT OF ORDERS OF MUSCINEÆ.

MUSCINEÆ	...	{	{	...	{	Bryaceæ. Ex.: Feather Moss.
						Phasaceæ. Ex.: Earth Moss.
						Andreaceæ. Ex.: Andrea.
						Sphagnaceæ. Ex.: Bog Mosses.
						Jungermanniæ. Ex.: Liverworts.
						Marchantiæ. Ex.: Marchantia.
		{	{	...	{	Monocleæ.
						Ricciæ. Ex.: Waterworts.
						Anthocerotæ. Ex.: Nardoo.

Berkeley divides mosses into five groups:

1. Pleurocarpi	}	...	...	...	Bryaceæ.
2. Cladocarpi					
3. Acrocarpi					
The group Phaseei of Acrocarpi					Phasaceæ.
4. Schistocarpi	...	...	...	...	Andreaceæ.
5. Syncladci	...	...	...	...	Sphagnaceæ.

Many of the mosses and liverworts are cosmopolitan. For particulars of these plants, see Berkeley's Handbook of British Mosses. See also Hooker and Taylor's Muscologia Britannica, 1827; Australian mosses, Mueller, 1864; Bryologia Britannica, Wilson; "mosses of the East Indies,"

Mitten, Journal of the Linnæan Society, iii, 1859 (Supplement); and Synopsis Muscorum Frondosorum, Müller. For the minute structure of the Muscineæ, see Sachs' Text-book of Botany, translation by Bennet and Thistleton Dyer.

CLASS I.—MUSCI.

In mosses, the *sexual generation* is developed from the spore with the intervention of a *protonema*, often densely filamentous, and consists of filaform stems, furnished with leaves in two, three or four rows, usually without any bilateral structure, and generally branching in a monopodial, never in a dichotomous, manner (modes of branching, see page 15).

In most mosses, the protonema disappears after it has produced the leafy stems as lateral buds; but where these latter remain very small and have only a short term of life, as in the Phascacæ, &c., the protonema still remains vigorous after it has produced the leafy plants, and when the sporogonium has already been developed upon them. In such cases, all three stages of the cycle of development are present simultaneously in genetic connection.

The leaf-bearing plant, which afterwards produces the sexual organs, originates from the lower cells of the lateral branches of the protonema. "The sexual organs of mosses usually occur in considerable numbers at the end of a leafy axis surrounded by enveloping leaves often of peculiar shape; a compound structure of this kind may, for the sake of brevity, be called a '*Flower*.' Within a flower, either both antheridia and archegonia are produced, or it contains only one kind of sexual organ. The flowers may then be either monœcious or dioecious;" the antheridia are, when mature, stalked sacs with a wall consisting of a single layer of cells; in most mosses they are of an elongated club-shape. The archegonia consist, when mature, of a moderately long base, which supports a roundish ovoid ventral portion; above this rises a long thin neck.

The *asexual generation*, or sporogonium, is formed in the archegonium. After impregnation, the oospore develops into the sporogonium, within the archegonium, which latter grows with it and becomes the *calyptra*. Although growing

within the tissue of the sexual generation, the spore-case has no organic connection therewith.

Fig.2 24.



The capsule with operculum, &c., of *Polytrichum*.

Within the sporogonium (*theca* or *urn*) a number of spores are formed, and when they are mature, the stalk (seta), or pedicel, rapidly becomes elongated, thus throwing off the calyptra (veil); the neck of the archegonium, the wall of which assumes a deep red brown colour, still for some time crowns the apex of the calyptra. A large part of the central tissue of the capsule remains sterile as the so-called *columella*; the upper part (operculum) of the capsule usually becomes detached from the lower part (the urn) in the form of a lid, in order to allow the spores to escape.

“The vegetative reproduction of mosses is more copious and varied than is the case in any other section of the vegetable kingdom. It presents the peculiarity that the production of a new leaf-bearing stem is always preceded by the formation of a protonema, even when the propagation takes place by gemmæ (see page 15). Exceptions are afforded only by the few cases in which leafbuds become detached, and commence immediately to grow.” In some species, it is sufficient to keep a tuft of moss damp for some days, and turned downwards, in order to produce hundreds of new plants in this manner.

No plants are so easy to prepare for the herbarium as mosses; they easily part with any moisture which they have imbibed, and if common care is used, they are not liable to be spoiled by damp or seriously injured by the depredation of insects.

ABSTRACT OF ORDERS OF MOSSES.

Mosses may be distributed naturally into four parallel orders:

Bryaceæ.	|	Andreaeaceæ.
Phascaceæ.		Sphagnaceæ.

Order I.—Bryaceæ

Are mosses, with small and scale-like leaves, usually spirally arranged. The sporogonium is always stalked,

and the seta is usually of considerable length. The theca is covered by a calyptra, and opens by throwing off an operculum. The Bryaceæ include a large number of genera.

Order II.—Phascaceæ

Are small mosses, and may be considered as the lowest form of the Bryaceæ. They are usually found covering the earth with a green crust, which ultimately develop into tiny plants. The short stems remain attached to the protonema, until the spores are ripe. The sporogonium (urn) does not open by an operculum, but allows the escape of the spores only by its decay.

Order III.—Andreaeaceæ

Are small tufted mosses with blackish red foliage, which gives them a burnt-up appearance; they are very leafy and much branched, the leaves being imbricated in eight rows. The sporogonium has constantly a terminal position on the stems of the sexual plants, and sessile on a slightly elongated stalk-like receptacle: the ripe theca does not open by an operculum, but by four longitudinal slits at the side; this last peculiarity is characteristic of the order.

Order IV.—Sphagnaceæ

Are aquatic plants of cold and temperate climates, with peculiar yellowish green aspect, imbricate leaves, and fasciculate branches. The sporogonium (urn) is sessile on an often much elongated receptacle (pseudopodium). The sporogonium dehisces by an operculum and is destitute of a peristome. In the sporogonium two kinds of spores are produced, the larger of which only germinates. The Sphagnaceæ include only a single genus.

CLASS II.—HEPATICÆ.

The *sexual generation* arises direct from the spore, or from a rudimentary pro-embryo developed on a dichotomously branched (see modes of branching, page 15) thalloid stem; the mode of growth is distinctly bilateral. In the

greater number of families and genera the vegetative structure is a broad, flat or curled plate of tissue. The leaves of all foliose Hepaticæ are simple plates of cells, in which even the mid-rib usual in the leaves of mosses is always wanting.

The *asexual generation* or sporogonium remains surrounded by a *calyptra* (the ventral portion of the archegonium) until the spores are ripe. The mother-cells of the spores arise from the whole of the internal cells of the sporogonium, or the intermediate cells become developed into elaters. The spores escape through the dehiscing of the capsule in valves. The external form and internal structure of the sporogonium are very different in the different groups. The propagation by gemmæ is very common and characteristic; the sexual organs are formed in the thalloid forms, on the upper side exposed to light. In the foliose forms the origin of the antheridia and archegonia is very various, and they are also developed in different ways. The antheridium consists, in the mature state, of a pedicel surmounted by a globular or ellipsoid body.

ABSTRACT OF ORDERS OF HEPATICÆ.

The Hepaticæ are usually divided into five orders, *viz* :

- | | |
|-------------------|-----------------|
| 1. Jungermannicæ. | 4. Ricciæ. |
| 2. Marchantiæ. | 5. Anthocerotæ. |
| 3. Monocleæ. | |

Order I.—Jungermannicæ

Are plants with distinct stem and leaves imbricated in a distichous manner, which gives a flattened character to the branches; the sporogonium (capsule) bursts into four valves and contains elaters.

Order II.—Marchantiæ

Are small green plants, with a thalloid stem, in the form of a lobed leaf-like cellular expansion. The sporogonia are collected on a stalked organ, and burst by four valves; they contain elaters.

Order III.—Monocleæ.

This order contains transitional forms between the Anthocerotæ and Jungermannieæ. The long sporogonium has a longitudinal dehiscence, and no columella. The first, or sexual generation, is either thalloid or foliose.

Order IV.—Riccieæ.

In these plants the thallus is leaflike, and floats on water, or in some species is terrestrial and attached by root-hairs. The sporogonium is imbedded in the thallus, and does not project above it; it is indehiscent and contains no elaters. The spores escape on the decay of the surrounding tissue.

Order V.—Anthocerotæ.

The thallus is flat and irregularly branched. From the archegonium springs a pod-like capsule, which dehiscs longitudinally into two valves when ripe. A columella is present; the elaters have no spiral bands.

DETAILS OF ORDERS OF MUSCINEÆ.

Order I.—Bryaceæ.

The Bryaceæ, or true mosses, are very plentiful in India, particularly in the hills. In these plants the sporogonium is always stalked, and the seta is usually of considerable length; the theca always opens by an operculum, which is either simply detached from the upper part of the theca, or a layer of epidermal cells (annulus) is thrown off with the operculum. The opening of the theca is mostly furnished with appendages, separately termed *teeth*, or collectively *peristome*. If the peristome is wanting, the sporogonium is *gymnostomous*.

The genus *Polytrichum* (hair-mosses), to which the largest and most highly developed mosses belong, differs from the other genera in several points in the structure of the theca. The teeth of the peristome are composed of thickened pro-senchymatous cells arranged in bundles of a horse-shoe

shape. The teeth are from 32 to 64 in number. When the operculum is thrown off, a layer of cells remains uniting the points of the teeth. The genus *Dicranum* (fork-mosses) include a large number of species. *D. palustre* is a large handsome moss, with yellow, green glossy foliage; the leaves are broad at the base with serrated edges; the urn is nearly erect, chestnut coloured, and has a beaked operculum. The genus *Tortula* (screw-mosses) have long narrow urns growing on erect seta (stalks); the teeth are long and slender, and twisted round the columella (pillar in the centre of the urn); the operculum (lid) is long and beaked. These mosses are very common, particularly in the hills. The genus *Grimmia* comprises a large group of tufted mosses, growing on rocks; erect when small, prostrate when mature; the operculum is convex and slightly pointed. The columella falls away with the operculum (as limited by some botanists the columella does not fall away but shrivels within the urn). The hair-mosses, *Pogonatum*, are very showy plants. *P. aloides* has lance-shaped dentated leaves and an oval urn; when moist the leaves are spreading, but they cling close to the stem when dry. The genus *Bryum*, or thread-mosses, are also a large group; they grow in tufts, on trees, rocks, and banks, with pear-shaped drooping urns and stem clasping leaves. *Mnium* have generally large leaves, which, when examined through the lens, are seen to be dotted and edged with a thick border. The upper leaves are larger than the lower ones, and are arranged in a star-like form; the urns are large and oval. The genus *Funaria*, or cord-mosses, have the seta very much twisted. *F. hygrometrica* flourishes on wood ashes, and almost everywhere. The bladder-mosses (*Physcomitrium*) have pear or club-shaped urns on an erect or slightly curved seta; the operculum is covered by an inflated calyptra; this last peculiarity gives the name to the genera. The flat forked-mosses (*Fissidens*) are numerous; they are very small plants; the leaves are placed alternately on either side of the stem, which sometimes gives them the appearance of minute ferns; the operculum is mitre-shaped. *Anomodon* is commonly found growing on the roots of trees and of rocks; it has long branches interlacing one another. The genus *Leskea* are feathery mosses with oval urns, on erect

stems, which peculiarity distinguishes them from the genus *Hypnum*, the true feather-mosses, which have curved seta; the urns also are generally slightly bent. Other genera are: *Leptotricum*, *Trematodon*, *Dicranella*, *Barbula*, *Racomitrium*, *Philonotis*, *Meteorium*, *Stereodon*, *Neckera*, &c. (For further particulars, see authorities named, page 246.)

Order II.—Phascaceæ.

The Phascaceæ are small mosses, the theca is without an operculum, and the spores escape on the decay of the sporogonium. These earth mosses are very small, covering the ground with a green crust at first. They die away in a short time. The capsules have little or no stalks. The leaves are generally in eight rows, and the whole plant is wonderfully minute.

Order III.—Andreaaceæ.

These mosses are in India, found only at considerable elevations in the Himalayas. They are small caespitose plants, very leafy and much branched with blackish red foliage, which gives them a burnt appearance. This curious order of mosses has some striking points in common with the Jungermannieæ, particularly in its 4-valved capsule and irregularly torn calyptra; thus connecting the Hepaticæ with the Musci. The capsule has, however, a central columella, and is terminated by an evident, though persistent, operculum.

Order IV.—Sphagnaceæ.

The Sphagnaceæ include only the single genus *Sphagnum*. The stem in these plants is repeatedly branched, and these again are much divided. The urns are globular (without a peristome) placed on very short seta. *Sphagnum* in India is only found in the hills. Mr. J. S. Gamble, who has made a large collection of mosses at Darjiling, informs me that he only once found a *Sphagnum* in that neighbourhood, and that at the summit of Tonghoo, 10,000 feet elevation. The epidermal tissue of the stem, &c., is provided with broad thin-walled empty cells, which

serve as a capillary apparatus for the plant through which the water in which it grows is raised up and carried to the upper part, hence it results that the *Sphagna*, which always grow erect, are penetrated with water to their very summits like a sponge, even when their tufts stand high above the surface of the water.

Order V.—*Jungermannieæ*.

The greater number of the plants of this order form slender filiform stems with numerous sessile leaves; these leaves are sometimes arranged in two rows, situated on the upper side as in *Radula*. Usually, however, we find three rows of leaves, one being developed on the under or shaded side (*Amphigastria*), the other two rows on the upper side. The principal genera are: *Jungermannia*, *Plagiochila*, *Lepidozia*, *Mastigobryum*, *Calypogeæ*, *Radula*, *Madotheca*, *Lejeunia*, and *Frullania*.

Order VI.—*Marchantieæ*.

The *Marchantieæ* are minute green plants with a thalloid stem extending flat upon the ground; the underside produces a number of root-hairs, the upper side is covered by a very distinctly differentiated epidermis having large stomata of peculiar form. The antheridia and archegonia are borne on separate stalked receptacles, which should not be confused with the sporogonia of other groups. The principal genera are: *Marchantia*, *Dumortiera*, *Grimaldia*, and *Fimbriaria*.

Order VII.—*Monocleæ*.

The *Monocleæ* contain transitional forms between the *Jungermannieæ* and the *Anthocerotæ*.

Order VIII.—*Riccieæ*.

The *Riccieæ* are minute plants found floating in water, among Lemna, or rooting in the ground.

Order IX.—*Anthocerotæ*.

These plants, which grow on loamy ground, have a perfectly leafless flat thallus; its irregularly developed rami-

fications forming a circular disk. In *A. punctatus*, adventitious shoots proceed from the margin of the thallus, and also from the upper surface.

GROUP III.—THALLOPHYTA.

Under this term are comprised Algæ and Fungi (Lichens being also included in the latter section).

The term Thallophyte is an adequate one, in so far as it points out one prominent property of the external conformation of most Algæ and of all Fungi; but a sharp boundary line cannot be drawn in this respect between the Algæ and Fungi and the group Museinæ.

The cellular structure of the plants of this group is their principal bond of connection; and their most striking character of distinction from the higher Cryptogams; the extraordinary variety of the forms and mode of life of the *Thallophyta* render it impracticable to characterize them collectively by giving a prominence to any other special feature of their growth or reproduction, especially alternation of generation, as may be done in the higher groups of the Cryptogamia.

The lower forms of the two divisions of the Thallophyta are very closely connected on account of their great simplicity of organization, which excludes the possibility of many different characters; it is therefore impossible to lay down accurate lines of demarcation between these two divisions: it may, however, be stated broadly that *Algæ contain chlorophyll*, and are therefore able to assimilate inorganic substances; while, on the other hand, *Fungi contain no chlorophyll*, and are therefore unable to make use of unassimilated food materials, but are found to live as parasites in other organisms, or on organic remains.

In arranging the two divisions of the Thallophyta, it is perhaps best to follow the classification adopted in the fourth edition of Sachs' "Lehrbuch der Botanik," in which Algæ and Fungi are arranged under four classes, dependent on the nature of their reproductive organs, each class consisting of two parallel series; the first series (Algæ) containing chlorophyll, the second series (Fungi) containing none. (See Sachs' Text-book of Botany, translated by Bennet and Dyer.)

ABSTRACT OF ORDERS OF THALLOPHYTA.

*Algae.**Fungi.*

Carposporeæ ...	{ Characeæ. Ex.: Chara. Florideæ. Ex.: Red Seaweeds. Coleochaetæ.	{ Basidiomycetes Ecidiomycetes (rust). Ascomycetes	... { Tremellini (Tremella). Hymenomycetes (Mushrooms). Gasteromycetes (Puffballs).
Oosporeæ ...	{ Fuaceæ. Ex. Large marine Algae, as the Gulf-weed. Ædogeniæ. Ex.: Ædogenium. Siphoniæ. Ex.: Vaucheria. Sphaeropleæ.	{ Tuberaceæ (Truffles). Pyrenomycetes (Claviceps, ergot). Discomycetes (Peziza, cup fungi). Erysiphiæ (Mildew). Lichenes (Lichens).	... {
Zygosporeæ ...	{ Conjugatæ. Ex.: Desmids & Diatomes. Hydrodictyæ. Ex.: Pediatrum. Volvocinæ. Ex.: Protococcus.	{ Saproleginiæ (Fungi growing chiefly in water on the bodies of putrifying insects). Peronosporæ (Potato and Poppy disease).	{ Zygomycetes, Mould on bread, etc. Myxomycetes (see page 283).
Protophyta ...	{ Cyanophyceæ. Ex.: Nostoc. Palmellaceæ. Ex.: Palmella.		{ Saccharomycetes, Yeast plant. Schizomycetes, Bacterium-Bacillus.

THALLOPHYTA,

ABSTRACT OF ORDERS OF THE CRYPTOGRAMIC GROUP.

THALLOPHYTA.

Class I.—CARPOSPOREÆ.

The result of the fertilization of the female organs by the antherozoids is the production of a fruit-like body, in which a number of cells, besides the true reproductive cells, take part, and in which are produced the carpospores, which ultimately germinate.

Order I.—Characeæ

Are submerged fresh-water plants with verticillately branched stems, the ultimate branchlets resembling linear leaves. Reproductive organs, nucules (female organs), and globules (male organs).

Order II.—Florideæ

Are marine Algæ, mostly of a red or violet, rarely of an olive, purple, or brownish colour; form variable. They are propagated sexually by means of carpospores formed in capsular fruit-like cells. The antherozoids are not endowed with independent motion.

Order III.—Coleochatæ

Are minute fresh-water green Algæ, constructed of branched rows of cells attach-

Order I.—Basidiomycetes

Are Fungi growing on dead organic matter. From the mycelium (a structure developed from the spore) is produced the asexual generation, which is ordinarily called the mushroom or receptacle, usually bearing quaternary asexual spores at the apex of erect basidia (projecting portions of the Fungus).

Order II.—Æcidiumycetes

Are Fungi parasitic on living plants; the carpospores are developed from the mycelium beneath the epidermis of the leaf. The fruit-like structure (æcidia), when mature, breaks through the epidermis of the leaf, and forms an open cup, in which the spores are produced.

Order III.—Ascomycetes.

The asexual generation comprises a greater variety of forms than any other

ed to the submerged parts of other plants, and forming circular discs. The carpogonium is always the terminal cell of a branch. They produce swarmspores.

order of Fungi. The common characteristic by which all the different forms are connected, is the asexual formation of spores in the interior of sacs (asei).

Class II.—OOSPOREÆ.

Reproduction takes place by oospores (fertilized oospheres) resulting from the fertilization of a large oosphere (female or germ-cell) by minute antherozoids (male or sperm-cell).

Order I.—Fucaceæ

Are olive-coloured seaweeds of a cartilaginous texture, usually attached to rocks by a discoid base. The oospheres are set free by the bursting of the oogonia, and are fertilized outside the plants by the antherozoids, and the fertilized oosphere at once develops into a new individual.

Order II.—Ædogoniæ

Are fresh-water filamentous Algæ, usually attached to the submerged parts of other plants. The thallus consists of unbranched or branched rows of cells. The spermatozoids and oospores are formed in the cells of the filaments.

Order III.—Siphonæ

Are plants living on damp earth, or in water, consisting of a single though much branched tubular cell; the

Order I.—Phyeomyceetes

Are unicellular filamentous colourless parasites. This order may be divided into two sub-orders—the *Saproleginiæ* and the *Peronosporæ*. The plants in both sub-orders form spherical oogonia (special organ of the mother plant in which the germ-cell lies) at the end of the mycelium structure, in each of which one or more oospores result from fertilization.

The *Saproleginiæ* mostly grow on the bodies of insects putrifying in water.

The *Peronosporæ* live in the interior of Phanerogams; the branches of their unicellular mycelium growing between the cells of the tissue from which they draw their nourishment, as in the tubers of the potato.

free part of the cell that does not penetrate the ground contains a parietal layer of protoplasm with abundance of chlorophyll, but forms no nucleus.

Order IV.—Sphæropleæ.

A group of green filamentous Algæ.

Class III.—ZYGOSPOREÆ.

In this class the reproduction takes place by the union of two apparently similar cells. The class may be divided into two divisions according as the conjugating cells are motile or stationary. The product of the coalescence surrounds itself with a firm cell-wall, and is termed a *zygospore*; which generally germinates only after a long period of rest.

CONJUGATING CELLS STATIONARY.

Order I.—Conjugatæ.

In the *Mesocarpeæ* and *Zygnemææ*, conjugation takes place between cells belonging to distinct unbranched filaments. In *Desmidiææ* and *Diatomacææ*, between isolated cells.

Order I.—Zygomycetes.

Infest dead or dying parts of plants, especially fleshy fruits, which quickly decay in consequence of their attacks; the mycelium is unicellular, and much branched.

CONJUGATING CELLS LOCOMOTIVE.

Order II.—Hydrodictyææ

Are fresh-water plants, distinguished by forming a large number of swarm-spores, which, when they come to rest, unite into a single family; net-like in *Hydrodictyon*, tubular in *Pediastrum*.

Order II.—Myxomycetes.

These plants consist in their vegetative condition of masses of naked protoplasm (plasmodia), which possess a creeping motion on the substratum of decaying matter, earth, &c., on which they grow.

Order III.—Volvocineæ

Are microscopic Algæ living in colonies, which, during the whole of their vegetative period, are continually in motion, the motion, as is usually the case with swarm-spores, being caused by two cilia.

Class IV.—PROTOPHYTA.

No sexual mode of reproduction is known in these plants; propagation takes place by fission only.

Order I.—Cyanophyceæ

Are unicellular Algæ of thread shaped, or moniliform rows of cells, usually simple, rarely branched, enclosed in gelatinous sheaths, by which they are united into large colonies. They live in water and damp places.

Order I.—Saccharomyces

Are Fungi consisting of branched rows of roundish or ellipsoid cells which grow in saccharine fluids; and in growing cause the decomposition of the fluid with formation of alcohol, &c.

Order II.—Schizomycetes

Are most minute organisms, spherical and solitary, or rod-like, and united in filaments, characterized by the ease with which they break up into separate cells, as soon as they come into contact with the atmosphere.

ALGÆ.

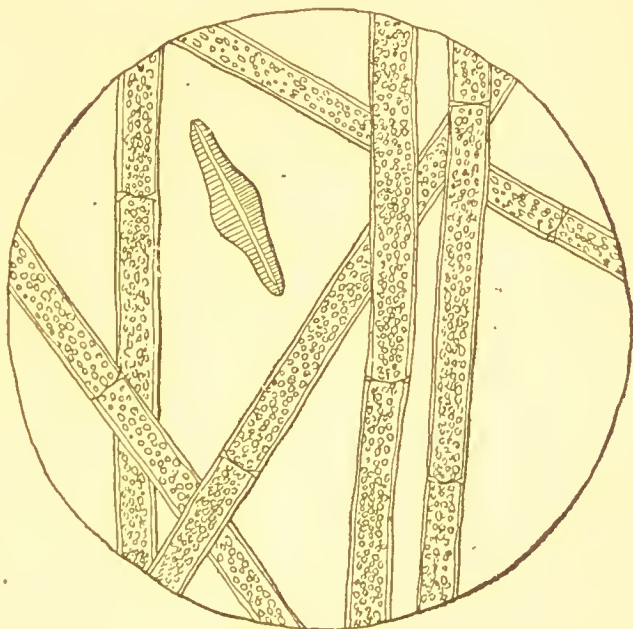
The Algæ are cryptogamic plants living in water or in damp places exposed to the light, always containing chlorophyll; they are extremely variable as to form, size, and colour. They include some of the smallest and simplest forms of the vegetable kingdom, rising in other instances to a high degree of organization and considerable dimensions. The development of the mass of Algæ is attained in

different ways,—sometimes the single individuals increase, as occurs in the most perfect forms, Characeæ, &c.; at other times numerous individuals are united into a genetic and organic whole, which behaves as an individual, as in the gelatinous Algæ (Nostocaceæ, &c.); they are all, however, exclusively cellular in structure and destitute of stomata.

In the cells of the lowest forms of this division nothing more can be recognized than a cell-wall containing a coloured protoplasmic substance; the latter always possessing a vacuole (fluid sap separated in the form of drops). A nucleus absent from the lower forms, is clearly present in

Fig. 226.

Fig. 225.

*Spirogyra* (magnified).

A common filamentous Alga (*Eldogonium*) found abundantly in fresh water tanks, also a unicellular Alga (*Diatome*).

the higher; the green protoplasmic substance sometimes forms granules, sometimes broad bands, often curved spirally, as in *Spirogyra*, sometimes discs, the forms of which are characteristic of particular genera.

The shape of the cell-wall is much less varied than in other classes of plants; the cell-walls of Algæ have a great tendency to become converted into a mucilaginous sub

stance. In the Diatomaceæ, great firmness of the cell-wall is obtained by the deposition of silica.

The mode of combination of the cells with one another is more various among Algæ than in any other class of plants; they are frequently arranged in a single row, or they form a flat surface, only one cell thick, or finally in the more highly developed forms of Algæ, such as in the various species of Characeæ, Fucus, Sargassum, &c., they exhibit the usual mode of formation of tissues which here makes their appearance for the first time in the vegetable kingdom; the outermost layer of cells being smaller and firmer, while the inner cells are often very large, and sometimes extremely long: and the entire process of growth is governed by a single apical cell.

The external differentiation of the Algæ in their higher forms resembles the difference that exists between stem and leaf, and to a certain extent even of roots. True roots, however, provided with a rootcap are altogether wanting (see section root, page 3). Sachs terms these leaf-like appendages *Phylloids*, and the root-like appendages *Rhizoids*.

The reproduction of Algæ is effected in a number of different ways; asexual reproduction is known in all the classes, sexual generation in the three higher; in numerous cases an alternation is found between asexual and sexual

generations. The lowest forms multiply by dividing into a number of cells or segments; this is the only mode of reproduction known in the *Cyanophyceæ* and *Palmellaceæ*; it is also very common amongst the Desmidiæ and Diatomaceæ.

Another remarkable form of asexual reproduction, which extends from the lowest up to the highest Algæ, is that known as reproduction by *swarm-spores* or *zoospores*; these

Fig. 227.



Development of swarmspores of *Oedogonium*:
a, a filament; *b* and *c*, joints breaking across to emit their contents; *d*, empty cell; *e*, swarm-spore; *f*, young *Oedogonium* (after Hensley).

result from the contraction of the protoplasmic substance

of certain cells, which are then reconstructed, escape through an opening in the wall of the mother-cell, and then swim about in the water for a longer or shorter time, like infusoria (the lowest class of animals), by means of two, four, or more cilia; they are microscopic and destitute of a cell-wall. After moving about for some time, the zoospores lose their cilia, become encysted, and grow into new Algæ; they occur in both fresh and salt water.

In the Florideæ (red seaweeds) a kind of gemma (see section bud, page 15) is formed termed a *tetraspore*, which consists of a parent cell divided into four chambers, the contents of which when set free from the parent plant grows up at once into new plants.

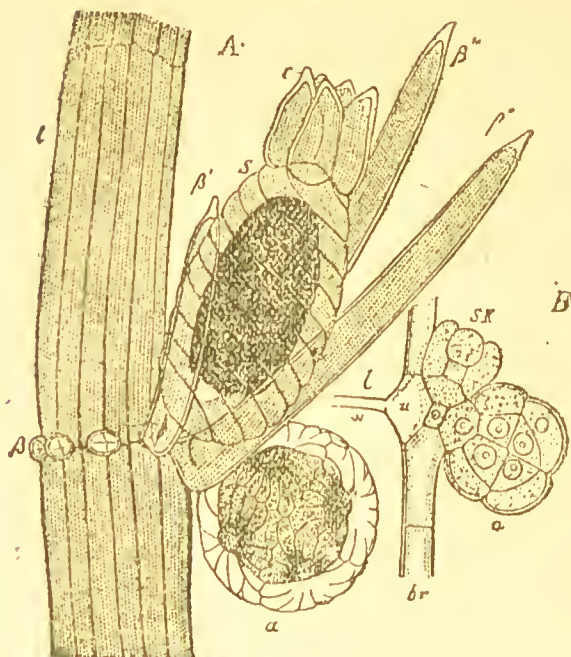
Sexual reproduction is brought about in different ways, the most important distinction being that the sexual cells may be either similar or dissimilar in size; in the former the reproduction is termed *conjugation*; this occurs in the class Zygosporæ; in the latter, *fertilization* or *impregnation*, the fertilizing body being termed a *spermatozoid*, *antherozoid*, *sperm* or *male cell*, the mass of protoplasm which has to be fertilized, an *oosphere*, *germ*, or *female cell*. The spermatozooids are formed in cells called *antheridia*, and when first emitted from these cells, are usually endowed with a power of locomotion; the female reproductive bodies or oospheres are formed in cells termed *oogonia*. In many sections of Algæ, especially in the fresh-water species, the mode of reproduction varies according to the generation (see page 225).

The chlorophyll in Algæ is frequently concealed by the presence of substances of a different colour. Fresh-water Algæ are mostly green, and are found plentifully in any stagnant water. Marine Algæ (for naming seaweeds, see Harvey's Algæ of the Southern Ocean, 1847) are chiefly of a brown, red, or olive colour; they are sometimes very large, and occur in great masses, particularly Sargassum bacciferum, which forms the celebrated masses of gulf-weed in the Atlantic Ocean.

Characeæ.

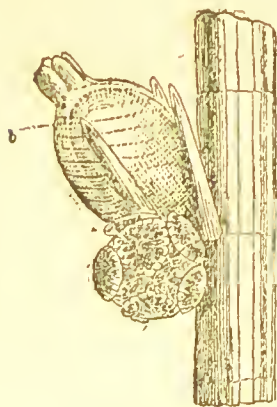
The Characeæ are submerged fresh-water monœcious or diœcious plants, rooting in the ground and growing erect; they have verticillately branched stems, the internodes of

Fig. 228.

*Chara fragilis* (after Sachs).

which (in *Chara*) consist of a central or axile cell surrounded in a spiral manner by other cells (see Fig. 228) which form a cortex.

Fig. 229.



A *nucule* in a monœcious *Chara* standing above the globule.

The reproductive organs are of two kinds,—to the male organs the term *globules* is given, while the female organs are called *nucules* (see Fig. 229). Globules and nucules stand on each side of the leaves. The globules are small globular bodies, the walls of which consist of eight flat cells, which in the ripe state are of a red colour; in the interior are a number of cellular jointed filaments, from each joint of which is developed a ciliated spermatozoid. The nucule is an ovoid body, somewhat larger than the globule. It consists of an axial row of cells closely surrounded by five tubes, which are coiled round it spirally (see Fig. 229); the whole is a metamorphosed shoot; the

oospore is developed as the result of impregnation from the large apical cell of the inner axial row.

There are only two genera, *Chara* and *Nitella*. In the *Nitella* each internode consists of only a single cell, while in the stem of *Chara*, there is a central or axial cell, surrounded in a spiral manner by other cells.

Chara verticellata, Roxb., grows in standing sweet water; it appears during the cold and hot seasons. The joints of the stem are somewhat prickly. *Chara flacida*, A. Braun, is very common in tanks and jheels in Bengal. *Nitella Roxburghii*, A. Braun (Jhang), is common in stagnant water in Bengal; the stems are smooth, and of a soft flacid texture; often several feet long. *Nitella oligospira*, A. Braun, grows in thick masses.

Florideæ

Are marine Algæ, mostly of a red or violet colour; the green chlorophyll grains being concealed by a red pigment, which can be extracted by cold fresh water.

Their sexual reproduction differs greatly from that of most other Algæ. The spermatozoids have no active motion, and are only moved about passively in the water, till they come in contact with a hair-like cell, the *trichogyne*, which is a long, thin hair-like hyaline sac, serving as a receptive organ and springing from a structure which is called the *trichophore*; near which the result of the fertilization becomes apparent; in its simpler forms this structure shows considerable resemblance to that of the Coleochætæ.

The asexual organs of reproduction take the form of *tetraspores*, which are not endowed with power of motion, and resemble in some respects the gemmæ of the Hepaticæ.

The red seaweeds are abundant in warm latitudes, occurring in deep water below tide-marks. Most of the Indian species can be found in the neighbourhood of the Andamans.

The abundant gelatinous substance of the thallus of many kinds, composed of a modification of cellulose, renders them nutritious. *Plocaria tenax*, Nees, is largely used by the Chinese for making glue. In the genus *Laurencia*, Lamx., the colour of the thallus is bright red, occasionally varying to pink or purple; the thallus is thickish, sometimes round, sometimes flattened. *Laurencia papillosa*,

Forsk. ; *L. obtusa*, Hudson ; *L. flagellifera*, Agh., are also common.

The *Glacelarias* are slender gelatinous seaweeds ; one species is used as an article of food in Ceylon. The genus *Hyphea* are slender plants. Several species of *Gelidium* are used by the swallows of the Malayan Archipelago and Cochin China for building their famous "edible nests."

Other genera are : *Chylocladia*, Ag. ; *Porphyra*, Ag. ; *Amphiroa*, Ag. ; *Melobesia*, Lamx. ; *Grateloupia*, Wulf ; *Polysiphonia*, Ag. ; and *Polocanium*, Huds. *Dictyota*, Lamx. ; *Padina*, Adans ; and *Dictyopteris*, Lamx., may also be placed under this order ; they are olive-coloured seaweeds with a continuous thallus.

Coleochætæ

Are minute fresh-water Algae, consisting of branched rows of cells attached in standing or slowly running water to the submerged parts of other plants, and forming circular closely-attached or cushion-like discs. The name of the order (sheath-hair) is due to the circumstance that certain cells of the thallus form hairs surrounded with sheaths. "The reproduction of the *Coleochætæ* is brought about by asexual swarmspores and by resting oospores produced sexually." The antheridia are formed at the same time as the oogonia in adjoining cells ; one antherozoid bearing two cilia is formed in each antheridium. The oogonium is always the terminal cell of a branch ; the effect of fertilization is seen in the formation of the oospore. The oospore divides within the oogonium, and from the cells thus formed swarmspores escape, which grow into new individuals. Several species of *Coleochætæ* can be procured in Bengal. They are all microscopic.

Fucaeæ

Are large, brown or olive-coloured seaweeds of a cartilaginous texture ; they are found attached to rocks or other Algae by simple or lobed discoid bases. The thallus branches dichotomously ; the ramifications all lie in one plane. The brown pigment can be extracted by cold fresh water. The tissue frequently becomes hollowed out into air-cavities which serve as swimming-bladders.

The antheridia and oogonia are formed in spherical hol-

lows termed *conceptacles*. The oospheres are set free by the bursting of the oogonia, and are fertilized outside the plant by the antherozoids. Sometimes the antherozoid are present in the same conceptacles as the oospheres; sometimes they are borne on a separate plant. The antherozoids are each provided with two fine cilia.

The Fucaceæ are universally distributed, especially on rocks between tide-marks or in deep water buoyed up by their vesicular floats. Their chief value is as a source of iodine, which is extracted from the ashes. *Sargassum bacciferum* forms the celebrated "gulf-weed" in the Atlantic Ocean; this species is also to be found in the Indian Ocean as well as *S. vulgare*, Ag., and *S. illicifolium*, Turner, &c. In the genus *Asperococcus*, the thallus is tubular, and the clusters of spore-cases are mixed with filaments. The genus *Mesogloia*s has the thallus much divided and thread-shaped. Other genera are: *Sphacelaria*, *Fucus*, &c.

Fig. 230.



Escape of a swarmspore of an *Ædognium*.

Ædogniaceæ.

The *Ædogniaceæ* include at present only the two genera, *Ædognium* and *Bulbochaete*. They are filamentous Algæ, consisting, in *Ædognium*, of unbranched rows of cells; in *Bulbochaete*, of branched rows. They are mostly attached to the submerged parts of other plants.

The reproduction of the *Ædogniaceæ* takes place by asexual swarmspores, and by oospores produced sexually. The oogonium is a cell of the filament itself. The mother-cells of the antherozoids are cells of the filaments, similar to the vegetative ones, but shorter and contain less chloro-

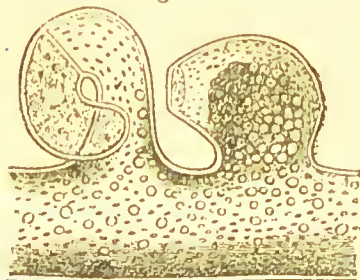
phyll; in most species, each of these cells divide into two special mother-cells, each producing one antherozoid. The antherozoids are very similar in form to the swarmspores, but much smaller; their motion due to cilia is also similar. The sexual plants are either monœcious or diœcious.

Alternation of generation takes place in the following manner: the oospores formed by the fertilization of the oosphere by the antherozoids, after remaining at rest for a considerable time, forms asexually usually four swarmspores, from which again similar ones proceed until the series of them is closed by a sexual generation. *Edogonium scutatum* is usually to be found in any stagnant fresh water.

Siphonocæ

Are found in fresh and salt water; they consist of a large single tubular, often branched, cell. The genus *Vaucheria* is the best known representative of this order. The thallus of *Vaucheria* is often several inches or a foot long, developing on damp shady earth or in water.

Fig. 231.



A portion of a plant of *Vaucheria*, showing an antheridium and an oogonium.

Besides the occasional multiplication by the separation of branches, reproduction is also brought about by asexual spores and by sexually produced oospores. All the species of *Vaucheria* are monœcious, and the two kinds of sexual organs are mostly found very near together. The antheridia are hook-shaped cells (see Fig. 231). The oogonia are spherical cells, formed close to the antheridia in which the oosphere originates by rejuvenescence.

The process of vegetation in the genus *Botrydium* approaches very near to *Vaucheria*.

The marine genus *Caulerpa* forms from its single large cell, creeping stem-like structures which grow at their apex, with descending branched rhizoids and ascending leaf-like branches.

Conjugatæ

Are distinguished from all other Algæ by their reproduction by the process of conjugation (see page 259). The cells of the Conjugatæ are distinguished by the most various configurations and the beautiful arrangements of the masses of ehlorophyll. In *Spirogyra* it occurs in parietal spiral bands. See *S. adnata*, *S. elongata*, *S. subæqua*, *S. nitida*, and *S. decimina*. In *Zygnema* it is arranged in radiate bodies, as in *Z. insigne*.

The *Desmideæ* belong to this order; they occur in all quiet pools of pure water, at the bottom, or adhering to other plants. The principal genera are: *Closterium*, Nitzsch; *Cosmarium*, Menegh; *Desmidium*, Agh., &c.

The *Diatomeæ* are nearly allied to the *Desmideæ*, but are readily distinguished from these and other unicellular Algæ by the possession of an epidermal covering of silex, which renders their form indestructable by the ordinary agents of decomposition; they are all exceedingly minute; and many of them are cosmopolitan (see Synopsis of the British Diatomaceæ, Smith).

Diatomes are found in enormous numbers at the bottom of salt and fresh water attached to the submerged parts of other plants. Besides the ordinary rotation of protoplasm in their interior, they exhibit a creeping motion.

Some of the common Indian genera are: *Cyclotella*, Grun; *Coscinodiscus*, Ehrb.; *Achnanthes*, *Synedra*, Ehrb.; *Nitzschia*, Rab.; *Navicula*, Bory; and *Pleurosigma*, Grun.

Volvocineæ

Are unicellular microscopical plants, which during the whole of their vegetative period live socially in colonies or singly; they are almost continually in motion, interrupted only by certain periods of repose. The motion, as is usually the case in swarmspores, being caused by two cilia.

Fig. 232.



A family of *Pandorina*, the cilia project free into the water, and produce by their vibrations rotating and progressive movement of the whole family.

The social species are, however, distinguished from swarmspores by the cells being surrounded, while in

motion, by a membrane of cellulose through which the cilia project free into the water. These curious and beautiful objects are found abundantly in old tanks.

Protococcus, a genus of unicellular Algæ, but imperfectly known, is usually referred to this family; these plants are found abundantly in the mud, where rain water collects and in similar situations. They vary in colour from bright green to bright red. They multiply with great rapidity by cell division. *Protococcus cohærens* is very common on walls of buildings exposed to the weather; hardly are the walls whitewashed, when they again turn black, being covered by this *Protococcus*. *P. vulgaris* is also a common species.

Cyanophyceæ

Comprise a large number of minute organisms, including the sub-orders *Oscillatoria*, *Nostocaceæ*, *Chroococcaceæ*, *Rivulariæ*, and *Scytonemæ*. The *Oscillatoria* (see Fig. 233) are microscopic filamentous structures, composed of continuous tubular sheaths enclosing a green or brown gelatinous matter marked by transverse striæ; the extremities of the filaments vibrate like a pendulum or with a slightly verminiform oscillation, whence the name of the group. *Oscillaria amphibia* may be frequently found forming slippery layers (of about one-eighth line thickness) on brick steps leading to tanks, &c., also submerged or near the surface of the water.

Fig. 233.



Free thread-shaped rows of cells of *Oscillatoria*.

The *Nostocaceæ* are plants formed of thread-like or moniliform rows of cells, usually simple, rarely branched. The filaments are enclosed in gelatinous sheaths, by the deliquescence of which they are often united into large colonies which form either roundish or membranous wrinkled masses [Nostoc, see Fig. 234]. *Nostoc gregarium*, Thuret, occurs commonly submerged in tanks.

Fig. 234.



Wrinkled mass of *Nostoc* formed of thread-shaped cells enclosed in gelatinous sheaths.

The *Chroococcaceæ* are unicellular, and agree with the *Nostocaceæ* in their tendency to associate in slimy masses, the difference lies in their cells not being united into filaments.

FUNGI.

The *Fungi* form the second parallel division of Thallophytes (see abstract, page 257); their vegetative elements consist of cellular filaments, destitute of chlorophyll, which rarely branch dichotomously, more usually by lateral shoots, and which grow only at their apices; these elementary constituents of Fungi are called *hyphæ*. It is only in the *Phycomyces*, a transitional group between *Algæ* and Fungi, that the entire vegetative portion of the Fungus consists of a single undivided cell.

The *hyphæ* either run parallel to one another, or their numerous ramifications are interwoven in various ways.

When these textures are very dense, they assume the form of a parenchymatous tissue, which is known as pseudoparenchyma; this tissue is especially developed in the larger Fungi, and can be well seen by boiling a portion of the receptacle of *Polyporus* in very dilute nitric acid and examining a section of it under the microscope.

The cell-walls of Fungi consist of a kind of cellulose; and the cells contain a characteristic fatty oil, but neither nucleus, chlorophyll or starch. Calcium oxalate is usually found on the surface of the *hyphæ* of Fungi. The absence of starch is not immediately connected with the want of chlorophyll. Since *phanerogamic* parasites like *cuscuta* (see page 159) and *orbanche* (see page 164), although they form no chlorophyll, yet contain abundance of starch.

Since Fungi do not form chlorophyll, they require for their nourishment the previous formation of an organic substance: many of them, therefore, are *saprophytes* growing on dead organic substances; others are parasites, growing on living animals or plants; others again are *endophytes*, living in other organisms; only a few are *epiphytes*, living upon them. *Saprophytes* allied to the *Schizomycetes* are the cause of the phenomena of fermentation, decay, and putrification.

The whole process of development of a Fungus may be

Fig. 235.



A fungus (Mushroom): the root-like structure is termed a mycelium; the stem and cap form the asexual generation.

divided into two periods: First, from the spore a mycelium is produced, which consists either of simple filaments or loose flocculent expansions or compact tuberous masses (sclerotia); these last are not peculiar to any particular group of Fungi; but occur in species of the most different

groups, like bulbs and tubers among Phanerogams. Second, from the mycelium arises the *receptacle*, on which the spores are developed; it is usually the most conspicuous part of the Fungus; the receptacle varies greatly in its external form, and is usually produced above ground. Thus the whole of the mushroom developed above ground is a receptacle.

The production of spores is almost always limited to a particular part of the receptacle, the *hymenium*; these hymenia never produce anything but asexual reproductive cells, but the hymenium bearing body itself may be the product of a *sexual process*.

The mode of reproduction of Fungi is even more various than that of Algae. Sachs states that "in those species the cycle of whose development is fully known, sexual and asexual reproduction occurs, or the latter is replaced by conjugation. In those cases where neither sexual reproduction nor conjugation has hitherto been observed, it may be assumed that our knowledge of the series of development is still incomplete, and that forms which are at present considered independent are really only mem-

bers of an alternation of generations (see page 255). It is important to note that it has been already ascertained that in many Ascomycetes, the receptacles which bear the Ascospores are the result of a sexual process which takes place in connection with the mycelium, so that the mycelium forms the first or sexual, the receptacle the second or asexual generation. In the Phycomycetes, on the other hand, the product of the sexual process is a *resting cell*, similar to what is found in many Algæ, while the origin of the receptacle of the Ascomycetes corresponds essentially with that of the Floridæ."

The systematic grouping of Fungi is still in process of continued change and improvement. Whole sections of genera of the earlier systems are now recognized as simple forms of development in the alternation of generations of other forms. For further particulars, see an Introduction to the study of Microscopic Fungi by M. C. Cooke, 1865; Handbook of British Fungi, Cooke, 1871; Sachs' Text-book, Bennet and Dyer's translation.

Basidiomycetes.

Although the largest and most beautiful Fungi belong to this order, yet their course of development is at present only very imperfectly known.

The *Basidiomycetes* (Basidium, a branch of the hyphæ on which the spores are developed, see Fig. 237) may be divided into the following three suborders: 1st Suborder *Tremellineæ* are Fungi of a gelatinous consistency; they are found growing on stumps of trees and on the ground; they collapse on drying; if, however, they are afterwards placed in water, they soon absorb it, and become again extended to their former size. *Tremella foliacea*, Fr., is of a rich claret colour, and of an irregular shape. *T. ferruginea*, Sm., and *T. protensa* are also common.

In the 2nd Suborder *Hymenomycetes* are included the commonest and best known of all Fungi (mushrooms). The structure, which is usually called the Fungus, is the receptacle (see Fig. 235). The hymenium (spore-bearing expansion of tissue) is spread over the under surface of the receptacle on projections of various forms which lie on the underside of the *pileus* or cap; on the stalk is some-

times found a ring or *annulus*, which is all that remains of a veil or covering (velum parziale) which united that part of the stalk with the outer edge of the cap or pileus,

Fig. 236.

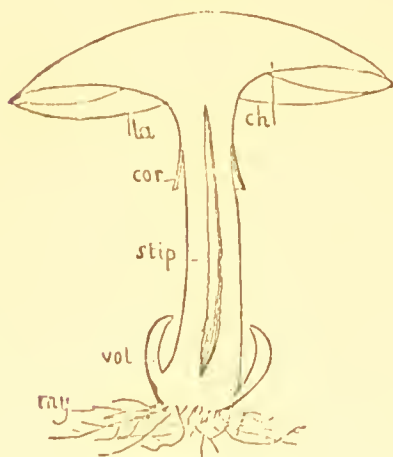
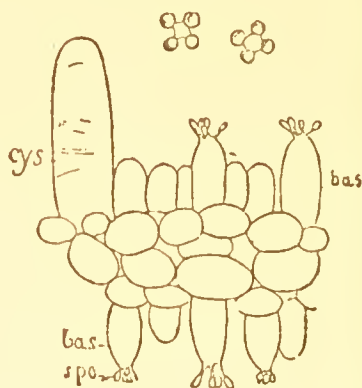


Diagram of an *Agaricus*; from the mycelium arises the receptacle (ch) supported on a stalk. (Stip) (la) the lamellæ (cor), the remains of the ruptured veil.

Fig. 237.



A portion of the hymenium of an *Agaricus*, showing (bas) Basidia on which the spores are formed; the sterile club-shaped cells are termed Paraphyses.

but was ruptured on the expansion of the latter, or sometimes the pileus and stalk are both enveloped in such a membrane (velum universale) or occasionally both are present. The species of *Agaricini* (mushrooms) are usually terrestrial in habit. In the *Polyporei*, the hymenium is spread over the cavity of tubes or pores. The texture of these plants is, as a rule, more cartilaginous than that of the *Agaricini*. The genus *Polyporus* includes a large number of species. *P. squamosus*, Fries., is familiar to most persons, growing like irregular brackets of great extent and considerable bulk at the base of stems of various trees. *P. versicolor* is also a familiar species, smaller than the last, but growing in great abundance, tier above tier, usually of an olive and yellow colour. The genus *Boletus* belongs to this group.

In the *Hydnacei*, the hymenium is spread over teeth or spines, which are soft, usually of the shape of an awl, and distinct at the base. *Hydnum zonatum* is a small fungus

of a reddish lilac hue, marked on the surface of the cap with darker zones; the centre becoming depressed. The *Merulius* group includes the plant known as dry root *M. lacrymans*, Fr.

The 3rd Suborder *Gasteromycetes* consists of fungi forming roundish angiocarpous receptacles consisting of an outer layer (peridium) enclosing masses of tissue on which are borne the hymenia. The Puffballs (*Lycoperdon*) are typical of this order. Other genera are: *Clathrus*, *Exidia*, *Geaster* (earth stars), *Bovista*, &c.

Æcidiumycetes.

The best known species of this order is *Puccinia Graminis*, Pers. (corn-mildew); it occurs on the leaves and culms of cereals and grasses, and is very common, and injurious to the plant. Its development not only shows a distinct alternation of generation, but that peculiarity by which one generation of a parasitic fungus is developed exclusively on one host, while another stage of development of the same species occurs only upon a different host. The term æcidium (cluster cups) is used to designate a particular form of fruit, in the cycle of development of Puccinia.

The æcidia (rust) are always developed on living plants, most commonly on the foliage leaves, usually on the under surface; leaves infected by these parasites present a singular appearance as if sprinkled with red dust. When examined closely small orifices are seen scattered over the under surface of the leaves; these cups (æcidia) appear to have burst through the epidermis of the leaves, and elevated themselves above its surface, with the lower portion attached to the substratum beneath; these cups are the fungi, the red dust the spores. The spores from these æcidia germinate beneath the epidermis of the leaves and stems of grasses, and were at one time considered as a distinct genus of Fungi, under the name—*uredo*.

The cycle of development is briefly this: from the resting spore a very minute mycelium (promycelium) is produced, and this usually divides into four cells, from each of which a minute cell (sporidium) is developed. On finding their way to a host (leaves of *Berberis*, for example) these spori-

dia germinate and their mycelium permeates the tissue, eventually developing fructifications (æcidia) on the under surface of the leaf and spermogonia on the upper surface. The spores which are formed on finding their way to a grass germinate, and form a mycelium in its tissue, and this produces two kinds of reproductive spores; one kind (the uredo spores) are 1-celled and germinate at once; the other (teleuto spores) are more than 1-celled and constitute the resting spores. To this order belongs *Ustilago carbo*, the smut of cereal grains. *U. segatum*, Ditin. (corn smut), occurs on the ears of cereals and grasses, and is very common.

Ascomycetes.

The Ascomycetes comprise a greater number of forms than any other order of Fungi. The common characteristic by which they are connected is the asexual formation of the spores in the interior of sacs (asci) by free cell formation. An alternation of generation has been clearly recognized, in so far as the receptacles in which the ascospores are produced, owe their origin to sexual union, which takes place on the mycelium. These fungi grow chiefly on the dead parts, or remains of plants, on living plants, or organic solutions.

The Ascomycetes may be divided into five suborders—*Tuberaceæ*, *Pyrenomycetes*, *Discomycetes*, *Erysipheæ*, and *Lichenes*.

The *Tuberaceæ* are fungi consisting of roundish tuberous bodies, usually found growing underground, and often surrounded by a branched mycelium; they may at first sight be easily confounded with the Gasteromycetes. The truffle (tuber) belongs to this order.

The Suborder *Pyrenomycetes* consists of fungi growing usually on dead organic bodies, and on living plants, and forming round or flask-shaped receptacles termed *perithecia*, which usually produce eight spores formed simultaneously. The perithecia usually open outwards by a small orifice, the internal cavity of which is lined by the soft hymenium. When the ascospores germinate, they produce a mycelium on which are formed: 1st, *conidia*; then 2nd, *spermatia*, enclosed in spermogonia;

and 3rd, *stylospores*, formed in the interior of *pycnidia*. Any of the members of these series may, however, be wanting, except the perithecia. The fungus *Claviceps purpurea*, which produces ergot, belongs to this suborder. Its development and structure is very complicated. Other genera are: *Sphaeria*, Berk., which has the appearance of stains or dots of every shade of brown: *Xylaria*, Hill: *X. hypoxylon*, Ehrb., is common everywhere; it has a charred appearance; the thallus is sometimes simple, sometimes branched: *X. polymorpha*, Pers., is club-shaped; it is black and heavy, and looks like charred fragments of wood on the decaying stump on which it is usually found.

The *Discomycetes* live on dead organic bodies; they are distinguished from the *Pyrenomycetes* mainly by the hymenium being superficial. This suborder includes *Peziza*, enormously rich in species; they are beautiful fungi of a cup-shaped form; the hymenium is spread over the inside of the cup. *P. aurantia*, Pers., is of a pale orange colour on the outside; the plants grow in clusters: *Geoglossum glabrum*, Pers., is a black tongue-shaped fungus. Other genera are: *Phacidium*, Fr.; *Phytisma*, Berk.; and *Bulgaria*, Fr.

The Suborder *Erysipheæ* (mildews) consist of fungi growing on the surface of living plants and dead organic bodies; they are especially abundant on preserved fruit. These fungi are sometimes included under the Suborder *Pyrenomycetes*.

The suborder *Lichenes* are the best known *Ascomycetes*, and until very recently they were thought to occupy a position in the vegetable kingdom, equal in importance to that held by the Fungi and Algæ; but the researches of some distinguished botanists show that they are *Ascomycetes* belonging to the suborders *Pyrenomycetes* and the *Discomycetes*, parasitic, or consorted with Algæ of the *Chroococcaceæ*, *Nostocaceæ*, *Palmellaceæ*, etc.; this mutual parasiticism, if it may be so termed, appears to be beneficial to both organisms.

The green parts (*gonidia*) of Lichens contain chlorophyll, and are algal bodies. From these Algæ the hyphæ of the fungal parasite extract nourishment for their own use. This theory has been confirmed by the production of a perfect

lichen, *Collema glaucescens*, by sowing its spores on the Alga *Nostoc lichenoides*; of the two components, the fungus is the superior, both in bulk and nature, and it is for this reason that the lichens are classed as Aseomycetes.

The spores of Lichens are produced in asci, which are formed in superficial cup-shaped receptacles, termed apothecia in the Discomycetes; perithecia in the Pyrenomycetes. Lichens are likewise reproduced by *soredia* (clusters of gonidia), which surrounded by a web of hyphæ becomes detached from the thallus and grow into new thalli.

The Algae hosts (gonidia) belong to the orders Chroococaceæ, Nostoeaceæ, and Palmellaceæ, &c. The fungi themselves have not been found in any other form than as parasites or Algae.

The greater number of lichens are found as incrustations on damp ground, on the bark of trees, and on stones. The thallus of lichens can be dried, so as to be pulverized, without losing its vitality. The following abstract shows at a glance one of the latest classifications of lichens:

LICHENS...	{	HETEROMEROUS— (Gonidia arranged in one layer.	{	FRUTICOSE— (Thallus attached only at one spot, and rising from it in the form of a shrub. Ex.: Usnea.)
				FOLIACEOUS— (Thallus in the form of flake-like expansions often curled, which can frequently be detached from the substratum.)
				CRUSTACEOUS— (Thallus in the form of incrustations. Ex.: Graphis.)
				GELATINOUS— Ex.: Collema, Leptogium, &c.
		HOMÖOMEROUS— (Gonidia and hyphæ about equally mingled.)	{	NON-GELATINOUS.

The disposition of the gonidia and hyphæ in a thallus may be such that those two structures appear about equally mingled; the thallus is in this case called *homöomorous*, or the gonidia are arranged in one layer, the

hyphæ being then separated into an upper and an under layer; such lichens are termed *heteromerous*.

Heteromerous lichens may be divided into fruticose,

Fig. 238.



Vertical section through the middle of a young apothecium of *Lecanora* (after Thomé).

constitutes a layer of uniform thickness round the thallus. The genus *Cladonia* is usually found growing on the ground. *Cladonia furcata*, Hoffn., has a brownish hue, and its branches are simple or only once forked. *C. rangiferina*, the reindeer lichen, is of a whitish colour; the form resembles that of a miniature tree, with round, sessile receptacles; it can endure almost any amount of heat and cold; it often grows to the height of 8 or 10 inches. In the genus *Stereocaulon*, the apotheciæ are flat. The genus *Usnea* is a very attractive one; the sections of the thallus are round, branched, and drooping. The long pendant *Usneas* are very characteristic of the upper forests above Darjiling. *Usnea barbata*, Fr., or the hairy *Usnea*, is jointed, very slender and long, and hangs like bunches of hair from the trees. *Alectoria jubata*, Ach., is usually found growing on the branches of coniferous trees, at high elevations in the Himalayas; the sections of the thallus are branched and are of a dark-brown colour. The genus *Ramalina* grow on decaying branches; and resemble diminutive shrubs. The most important species of the genus *Cetraria* is *C. islandica*, Ach., one of the nutritive lichens; it grows in upright olive-brown tufts; the thallus is paler on the underside than on the upper, and with a fringe of dark hairs; it grows most luxuriantly and plentifully in high latitudes. *C. stracheyi*, Bab., and *C. reticulata*, Kiplh., are also to be found in the Himalayas. The genus *Roccella*, from which litmus is obtained, belongs to this group.

foliaceous, and crustaceous. Homöomerous lichens may be divided into gelatinous and non-gelatinous.

In the fruticose lichens, the cortex commonly consti-

In the foliaceous lichens, the cortex is usually different on the upper surface, which is exposed to the light, from the under surface, which is shaded by the thallus. The genus *Solerina* contains but two species; its characteristics are the orbicular apotheciae and woolly veins. *S. erocea*, Ach., is of a yellowish green colour; the sunken apotheciae are chestnut-coloured; it grows on ground, on the top of mountains. The genus *Sticta* has depressed dots on the under surface of the thallus, which is large, lobed downy

Fig. 239.



A lichen (*Parmella*) with a portion of the bark of the tree from which it was taken; in the hollow cup-like structures are formed the spores.

beneath and free from the substratum except at the base. *S. pulmonacea*, Ach., is one of the handsomest of the lichens; the colour varies from a light-green to an olive-brown. The genus *Parmelia* contains some handsome and showy species. *P. eaperata* is a handsome lichen, pale-yellow above, dark-brown and hairy beneath. *P. perlata* is of a silver-gray colour. *P. saxatilis* is of a darkish-brown colour, lighter towards the margin. The genus *Leeanora* contains a large number of species. From *L. tartarea*, the purple die called cud-bear is obtained. *L. esculenta*, of Tartary, presents the strange anomaly of a free lichen, unattached to wood, stone, or earth, and drawing its entire nourishment from the air. The genus *Peltigera* also belongs to this group.

The thallus of the crustaceous lichens presents an affinity to that of the latter group in being fixed to the substratum by capillary or bristle-like rhizoids, so that it cannot be removed without injury. The genus *Lecidea* comprises a large number of species; the thallus is somewhat leafy and the apothecia are salver-shaped; the substance of the

thallus radiates in a regular form round the margin. *L. lutea* is of a pale-yellow colour; the apothecia being of a darker shade. In the genus *Arthonia*, the crust is thin and spreading and the apothecia round and sessile. These lichens form greyish stains dotted with tiny specks of brown or black upon trees. Other genera are: *Verrucaria* (the wartlichens), *Baeomyces*, *Pertusaria*, &c. The Pictorial lichens form thin patch-like incrustations on stones, and on the bark of trees; the chief peculiarity of their thallus consists in the nature of the gonidia, which are often united into rows of cells, increasing in length by the division of the terminal cell. There are two genera—*Opegrapha*, Pers., and *Graphis*. *Graphis scripta*, Ach., is to be found everywhere growing on the stems of trees (see Fig. 240).

Fig. 240.

*Graphis scripta*.

The thallus of the gelatinous lichens has a leaf-like or arborescent form, or consists of granules, which constitute an incrustation. When dry, it is cartilaginous or brittle, and then absorbs water eagerly, swelling up into a gelatinous body; the gonidia lie in an apparently homogeneous jelly-like tissue. *Collema* is a typical form of these lichens. The genus *Leptogium* is also characteristic of this group. (For determination of genera and species of lichens, see Leighton's Lichen Flora, 1872; also see list of authors cited,

page 574, Introduction to Cryptogamic Botany by Berkeley, 1857.)

Phycomycetes.

The Phycomycetes may be divided into two suborders—the Saproleginæ and the Peronosporæ. The Saproleginæ are fungi growing for the most part in water and chiefly on the bodies of putrefying insects, covering them completely with radiating cells; the contents of the oogonia are fertilized by the antheridia, which grow out in the form of tubes and pierce the oogonium to fertilize the germ-cell. The oospores, in germinating, produce a mycelium, which bear first asexual zoosporangia, and later the sexual organs; from the zoosporangia are produced zoo-

spores or swarmspores, which germinate and form a mycelium, from which arise again zoosporangia, and later the sexual organs; the sexual individuals are sometimes monœcious, sometimes diœcious.

The Peronosporæ are fungi parasitic on living Phanerogams, inducing in them speedy decay; they have a strong resemblance to the preceding suborder: the mycelium, which ramifies within the host plant, first bears the conidia (asexual reproductive organs) on branches, which in *Peronospora* protrude from the stomata of the plant on which they grow; in the genus *Cystopus* they are club-shaped, and form a hymenium beneath the epidermis: in some species the spores are not immediately capable of germination except when in contact with water, as for instance, drops of dew or rain; they then develop zoospores. *Peronospora infestans* is the cause of the potato disease, and *P. arborescens* is the cause of the poppy disease in India.

Zygomycetes.

The Zygomycetes are represented by the *mucorini*, which are fungi, growing on organic solutions, and consist of a densely branching mycelium, which bears both sexual organs and asexual sporangia; the root-like branches afterwards become multicellular by the formation of septa.

Mucor mucedo (see Fig. 241) infests dead or dying parts of plants, especially fleshy fruits, which quickly decay in consequence of its attacks; each of the ascending branches bears a sporangium within which numerous small spores arise; which are set free by the bursting of the wall of the sporangium; the zygospores (see page 259) are formed beneath the white felt-like texture of the mycelium filaments. *Penicillium glaucum* commonly appears on articles of food that have been kept for a few days. It presents, when examined under the microscope, the appearance of a miniature tree; the stem is simple, but bears at its summit a number of branches, resembling strings of beads.

Fig. 241.



Mucor mucedo
showing mycelium
bearing two sporangia.

Myxomycetes.

The Myxomycetes include a numerous group of organisms, which in many respects differ widely from all other vegetable structures, but in the mode of formation of their spores, stand nearest to Fungi. Their cells are without a cell-wall during the whole period of their vegetation and assimilation of food, and do not combine into a tissue; they live on decaying and rotting vegetable substance, such as tan, rotten stems, &c. When they reach the reproductive condition, the whole of the protoplasm becomes transformed into sporangia, or large receptacles. These sporangia are provided with a cell-wall, which varies in colour according to the species. The sporangia are filled with numerous spores, usually accompanied with thin wall tubes, opening one into the other; when the sporangium ruptures, the expulsion of the spores is assisted by these tubes (*capillitium*).

When a spore is saturated with water, it opens, and the whole of its protoplasmic contents escape as a roundish naked mass; but after some minutes, it assumes another form, becomes long and pointed at one end, where it is provided with long cilia; it is endowed either with a rotary motion, or creeps along, changing its form like an amœba (animal organism); these swarmspores multiply by division, but on the second or third day they cease dividing, and unite, two or more of them coalescing into a homogeneous protoplasmic substance, the *plasmodium*, also endowed with an amœba like motion. The plasmodia pass into a resting state, and become encysted, when the weather is dry, and can remain in this condition for months without losing their power of life. When the weather is moist and warm, the plasmodium again creeps out of these cysts.

Arcyria punicea, Pers., grows in abundance on dead wood; the spores are of a bright red colour. Other common Myxomycetes are: *Lycogala epidendron*, Fr.; *Reticularia entozantha*, Berk.; and *Cyathus Hoorkeri*, &c.

Saccharomyces.

The Saccharomyces are the yeast fungi, which cause the alcoholic fermentation of the saccharine juices of plants,

or of artificial solutions which contain sugar in addition to nitrogenous substances. These fungi consist of small roundish or ellipsoidal cells, which multiply by budding for an indefinite time, giving off bubbles of carbonic dioxide; the yeast plant also multiplies by endogenous segmentation of the cells; the protoplasm dividing into four subdivisions, around each of which a new cell-wall is formed; each individual is an ordinary vegetable cell, usually containing a vacuole, but no nucleus; the cells are either solitary, or associated in heaps or strings; their walls are formed of a modification of cellulose (the substance of which all vegetable cell membranes are formed), and mixed with which are minute quantities of sulphur, phosphorus, potassium, magnesium, and calcium.

Within the cells exist nitrogenous matter, in the condition of protoplasm, fatty matter, and water; the properties which determine these objects to be plants, are their power of forming protein, cellulose, and fat, out of a nutrient fluid of definite chemical composition, such as Pasteur's solution, which contains potassium phosphate, 2 parts; calcium phosphate, 2 parts; magnesium sulphate, 2 parts; ammonium tartrate, 100 parts; cane-sugar, 1,500 parts; and water, 8,394 parts.

Saccharomyces cerevisiæ can be easily seen by adding a small quantity of the juice (Taree) of *Phoenix sylvestris* (Khajoor) to a saccharine solution, letting the solution stand for about twenty-four hours, and then examining it with a one-eighth object glass.

Schizomycetes.

The *Schizomycetes* are the lowest forms of vegetable life known; they are usually present in great abundance whenever putrefying organic matter is found. All these organisms are characterized by the ease with which they break up into their separate cells, as soon as they come into contact with the atmosphere, from which circumstance they have received their name. They include the forms known as Bacteria, Vibriones, Spirilla, Bacillus, &c.; these organisms are placed among Fungi, as they show an analogy to them in their mode of life, since they obtain their nutriment from organic substances. Mr. D. D. Cunningham,

who has devoted considerable time to the study of these organisms, has forwarded to me the following note on Schizomycete forms common in the neighbourhood of Calcutta :—

“In regard to Schizomycete forms common in this neighbourhood, any number of form species of Bacterium, Basillus, and Spirochæte are to be obtained in all sorts of media. Various Bacterial and Basillar forms constitute a great mass of the contents of the lower portions of the intestinal tract in man and other animals, and as they are constantly liable to obtain access to the intrinsic nutritive fluids of the body, may often be detected in small numbers in these, quite apart from the existence of any morbid conditions in the host, but ready at once to undergo farther development and multiplication if, under any circumstances, conditions arise favouring them as compared with the intrinsic living units of the organism in the struggle for existence.”

DIRECTIONS FOR COLLECTING BOTANICAL SPECIMENS.

"Specimens should, if possible, be gathered in fine weather, and free from external moisture. In selecting them, care should be taken to have the plants in a perfect state of growth, with all the parts from which characters are taken. The entire plant, with roots, stems, leaves, and flowers, when practicable, should be preserved; and the roots should be washed before being put into the box of the collector. In the case of very large herbaceous plants or shrubs or trees, portions only can be taken. These should always be carefully selected so as to exhibit the characteristic organs. In the case of tall and slender Gramineæ and Cyperaceæ, the specimens may be folded once or twice backwards and forwards, and thus suited to the size of the paper used in forming the herbarium; and the folds may be secured during drying by being pushed into slits in small strips of paper. Ferns and many other tall plants may be preserved entire in the same way. A thick branch or stem should be split, so as to allow of pressure being applied; and very thick roots, as well as bulbs and corms, may be similarly treated."—*Balfour*.

One of the best and most interesting methods of impressing the characters of plants on the memory is to carefully botanize a selected route, then to make dissections of the different parts of the plants found, dry them separately, and afterwards glue them on paper in their proper order.

The plants found during a four hours' excursion of this kind on the 24th October 1880 between the Naihati railway station on the Eastern Bengal Railway and the village of Bhatparah, a distance of about four miles, are here given as an example (the names of all the plants found are given below, whether in flower at the time or not).

Microscopic and other plants not readily diagnosed should be preserved for further examination :—

Ranunculaceæ.

Naravelia zeylanica, D. C. (Chhágál báti).

Anonaceæ.

Anona squamosa, L. (Atá); *Anona reticulata*, L. (Nona).

Menispermaceæ.

Tinospora cordifolia, Miers (Gulancha).

Nymphæaceæ.

Nymphæa lotus, L.

Bixaceæ.

Bixa orellana, L. (Latkan).

Cruciferae.

Sinapis dichotoma, Roxb. (Surshá).

Capparidaceæ.

Gynandropsis pentaphylla, D. C. (Hurhuriyá). *Capparis horrida*, L.

Moringaceæ.

Moringa pterygosperma, D. C. (Sajíná).

Malvaceæ.

Sida humilis, Willd.; *Sida rhombifolia*, L. (Bárjálá); *Bombax malabaricum*, D. C. (Shimul); *Hibiscus vitifolius*, L. (Bánkápás); *Hibiscus esculentus*, L. (Dhenrus).

Aurantiaeeæ.

Limonia pentaphylla, Retz (Ash-shoura); *Citrus acida*, Roxb. (Nebú); *Ægle Marmelos*, Corr. (Bel); *Citrus decumana*, L. (Batavi-nebú); *Murraya exotica*, L. (Kamini).

Meliaceæ.

Azadirachta indica, Ad. Juss. (Nim); *Cedrela toona*, Roxb. (Tun).

Oxalidaceæ.

Oxalis corniculata, L. (Amrúl).

Vitaceæ.

Vitis pallida, W. and A. (Goáliya latá); *Vitis glauca*, W. and A. (Gargoáliya); *Leea crispa*, L. (Ban chálita).

Rhamnaceæ.

Zizyphus Jujuba, Lam. (Byar); *Zizyphus ocnoplia*, Mill (Shyákul).

Anacardiaceæ.

Odina wodier, Roxb. (Jiol); *Mangifera indica*, L. (Am); *Spondias amara*, Buch. (Amrá).

Sapindaceæ.

Nephelium Litchi, L; *Cardiospermum halicacabum*, L. (Shibjhul).

Crassulaceæ.

Bryophyllum calycinum, Salisb.

Leguminosæ.

Suborder Papilionaceæ.

Tamarindus indica, L. (Tinturí); *Dolichos lablab*, L. (Shim); *Dolichos sinensis*, L. (Barbati); *Cajanus indicus*, Spreng. (Arar); *Clitoria ternatea*, L. (Níl-áparájitá); *Phaseolus mungo*, L. (Hali mug); *Erythrina indica*, Lamk. (Pálitá mandar).

Suborder Cæsalpinieæ.

Poinciana pulcherrima, L. (Krishna churá); *Cæsalpinia Bonducella*, Flem. (Nátá); *Cassia Sophora*, L. (Kál kásundá); *Cassia fistula*, L. (Sondálu); *Cassia alata*, L. (Dádu mardan); *Bauhinia variegata*, L. (Rakt kánchan).

Suborder Mimosæ.

Acacia tomentosa, Willd. (Sálsáiu bábala); *Acacia Sirissa*, Buch. (Sirish).

Myrtaceæ.

Eugenia Jambolana, L. (Kála jám); *Psidium Guyava*, L. (Peyará).

Combretaceæ.

Terminalia Catappa, L. (Bádám).

Cucurbitaceæ.

Momordica charantia, L. (Karalá); *Luffa pentandra*, Roxb. (Dhundul); *Lagenaria vulgaris*, Ser. (Láo); *Trichosanthes cucumerina*, L. (Banpatol); *Benincasa cerifera*, Savi (Kumrá); *Coccinia grandis*, W. and A. (Tela kuchá).

Papayaceæ.

Carica Papaya, L. (Pepiyá).

Cactaceæ.

Opuntia Dillenii, Haw. (Nagphená); *Cereus hexagonus*, Haw.

Umbelliferae.

Hydrocotyle asiatica, L. (Thal kuri).

Rubiaceæ.

Nauclea Cadamba, Roxb. (Kadam); *Pavetta indica*, L. (Kukur churá).

Compositæ.

Vernonia cinerea, Less. (Chhota koksím); *Blumea lacera*, D. C. (Para koksím).

Plumbaginæ.

Plumbago zeylanica, L. (Chitta).

Ebenaceæ.

Diospyros embryopteris, Pers. (Gáb).

Asclepiadææ.

Calotropis gigantea, R. Br. (Akánda); *Dæmia extensa*, R. Br. (Chhágál bánti); *Hemidesmus indicus*, R. Br. (Anantum).

Apocynaceæ.

Vallisneria spiralis, Wall. (Haparmáli); *Thevetia nereifolia*, Juss. (Kaliká).

Jasminaceæ.

Nyctanthes arbor tristis, L. (Sinalí).

Boraginaceæ.

Heliotropium indicum, L. (Hátsurá).

Convolvulaceæ.

Ipomoea sepiaria, Koen; *Ipomoea reniformis*, Choisy. (Bluin kámri).

Solanaceæ.

Solanum ferox, L. (Rám begun); *Datura alba*, N. E. (Dhaturá); *Capsicum frutescens*, L. (Lal-langká-marich); *Solanum verbascifolium*, L. (Aras).

Verbenaceæ.

Clerodendron siphonanthus, R. Br. (Báman-háti); *Tectona grandis*, L. (Segun); *Vitex negundo*, L. (Nishinda); *Clerodendron infortunatum*, L. (Bhaut).

Labiatae.

Ocimum sanctum, L. (Tulsi); *Leonotis Sibirica*; *Leucas linifolia*, Spreng. (Halkasa).

Acanthaceæ.

Barleria dichotoma, Roxb. (Sádá játi); *Justicia procumbens*, L.; *Justicia Adhatoda*, L. (Bákas); *Acanthus ilicifolius*, L. (Hákuch-kánta); *Ruellia ringens*, Roxb. (Burigopáná).

Serophularineæ.

Lindenbergia ruderalis, L. (Haldi basunta).

Casuarineæ.

Casuarina equisetifolia, Forst. (Jáu).

Euphorbiaceæ.

Ricinus communis, L. (Bheranda); *Pedilanthus tithymaloides*, Poir. (Ráng-chitrá); *Ricinus dicoccus*, Roxb.;

Tragia involucrata, L. (Bichhati); *Euphorbia antiquorum*, L. (Tekátá-sij); *Euphorbia ligularia*, Roxb. (Mansásij); *Jatropha multifida*, L. (Croton, sp.); *Trewia nudiflora*, Spreng. (Pital).

Ulmaceæ.

Celtis orientalis, L. (Jíbun).

Urticaceæ.

Ficus Carica, L. (Dúmúr); *Ficus religiosa*, L. (Ashwath); *Artocarpus integrifolia*, L. (Kántál); *Urtica interrupta*, L. (Lal bichhati).

Nyctaginaceæ.

Boerhaavia erecta, L. (Purná).

Chenopodiaceæ.

Basella alba, L. (Puin); *Basella cordifolia*, Lam. (Puin shák).

Amarantaceæ.

Amarantus spinosus, L. (Kántá nati); *Amarantus gangesicus*, L. (Denga); *Deeringia indica*, Spreng. (Ghol mohaní); *Achyranthes aspera*, L. (Apang); *Alternanthera sessilis*, R. Br. (Shanchi).

Polygonaceæ.

Polygonum lanigerum, R. Br. (Páni-marich).

Hydrocharideæ.

Vallisneria spiralis, L. (Jhangi); *Hydrilla verticillata*, Casp.

Scitamineæ.

Musa sapientum, L. (Kalá); *Curcuma longa*, L. (Haldí).

Dioscoridææ.

Dioscorea anguina, Roxb. (Kukur-álu); *Dioscorea globosa*, Roxb. (Chupri-álu).

Smilacææ.

Smilax ovalifolia, Roxb. (Kumariká).

Commelinaceae.

Commelina bengalensis, Kth. (Kánchará); *Commelina communis*, Kth. (Jatá kánchara).

Palmaceae.

Phoenix sylvestris, Roxb. (Khajur); *Areca catechu*, L. (Supári); *Cocos nucifera*, L. (Nári-kel); *Borassus flabelliformis*, L. (Tál gáchh).

Aroideae.

Colocasia antiquorum, Schott. (Kachu); *Amorphophallus campanulatus*, Bl. (Ol); *Colocasia indica*, Schott. (Man-kachu); *Typhonium Roxburghii*, Schott. (Ghet-kachu).

Pistiae.

Pistia stratiotes, L. (Tákápáná); *Lemna polyrrhiza*, L.

Cyperaceae.

Cyperus rotundus, L. (Mutha); *Scirpus plantagineus*, N. E. (Chenchká).

Gramineae.

Panicum hirsutum, Kön. (Jálgántí); *Panicum*, sp.; *Saccharum officinarum*, L. (Uk); *Andropogon acicularis*, Retz. (Chor kántá); *Imperata arundinacea*, Cyrill (Ulu); *Cynodon Dactylon*, Rich. (Durba); *Bambusa arundinacea*, Retz. (Bánsh).

Polypodiaceae.

Pteris longifolia, L.; *Adiantum lunatum*, L.; *Adiantum cordatum*, L.; *Nephrodium molle*, Desv.

Bryaceae.

Hypnum bryoides, L.; *Tortula indica*, Hook.

Jungermanniaceae.

Jungermannia, sp.

Marchantiaceae.

Marchantia polymorpha, L.

Characeæ.

Chara verticillata, Roxb.

Conjugatæ.

Spirogyra elongata.

Navicula calcuttensis, Grun ; *Cyclotella striata*, Grun.

Volvocineæ.

Protococcus vulgaris ; *Volvox*, sp.

Oscillatorieæ.

Oscillatoria brevis.

Basidiomycetes.

Polyporus versicolor, Zipp ; *Polyporus squamosus*, Fries ;
Agaricus stillaticius, Berk. ; *Agaricus rubiæinctus*, Berk.,
Agaricus semiglobatus, Batch.

Ascomycetes.

Suborder Lichenes.

Graphis scripta, Ach. ; *Pertusaria communis*, D. C. ; *Par-*
melia perlata, Ach. ; *Bæomyces icmadophyllus*, L. ; *Arthonia*
subvelata, Nyl. ; *Lecidea lutea*, Dicks.

INDEX.

—:0:—

- Acanthaceæ, 167.
- Achene, 60.
- Acclamydeous, 34.
- Aerescant, 43.
- Aeminate, 26.
- Adhesion, 37.
- Adnate, 22, 48.
- Adventitious bud, 15.
- Adventitious root, 4.
- Ærial roots, 6.
- Æstivation, 16.
- Algæ, 260.
- Alismaceæ, 212.
- Alternation of generations, 225.
- Amarantaceæ, 179.
- Anaryllideæ, 197.
- Amentales, 85.
- Amphitropous, 55.
- Anacardiaceæ, 119.
- Anatropous, 55.
- Andræaceæ, 253.
- Andræcum, The, 48.
- Androphore, 36.
- Angiosperma, 80g.
- Angular divergence, 20.
- Anisostemonous, 37.
- Anonaceæ, 90.
- Anther, 48.
- Antherceroteæ, 254.
- Antheridia, 227.
- Antherozoid, 226.
- Apex of leaf, 26.
- Apocarpous, 53.
- Apocynaceæ, 150.
- Apopetalæ, 80l.
- Apophyllons, 47.
- Aposepalous, 42.
- Aquatic roots, 6.
- Araliaceæ, 141.
- Archegonium, 226.
- Arillode, 69.
- Arillus, 69.
- Aristolochiaceæ, 169.
- Aroideæ, 208.
- Arrangement of leaves in the bud
(abstract of), 17.
- Artocarpaceæ, 173.
- Asarales, 84.
- Aseidiomycetes, 275.
- Asclepiadaceæ, 152.
- Ascomycetes, 276.
- Asparagus, 5.
- Asterales, 80v.
- Aurantiaceæ, 113.
- Axes, 2.
- Axillary bud, 15.
- Basidiomycetes, 273.
- Begoniaceæ, 136.
- Berberidaceæ, 92.
- Berry, 60.
- Beta vulgaris, 5.
- Bignoniaceæ, 165.
- Bixaceæ, 99.
- Blade, 45.
- Boraginaceæ, 159.
- Botanical specimens (directions for
collecting) 285.
- Bracts, 19.
- Branching, 14.
- Bromeliaceæ, 199.
- Bryaceæ, 251.
- Bud, 15.
- Bud scales, 19.
- Bulbils, 16.
- Bulbs, 8.
- Cactaceæ, 139.
- Caducous, 42.
- Cæsalpiaceæ, 123.
- Calycifloræ, 80r.
- Calycifloral, 37.
- Calyptra, 245.
- Calyx, 41.

- Cambium, 80*i*.
 Campanulales, 80*w*.
 Campanulate, 45.
 Campylotropous, 55.
 Cannabinaceæ, 175.
 Capitulum, 38.
 Capparidaceæ, 98.
 Capsule, 58.
 Carcerulus, 60.
 Carina, 45.
 Carpophore, 36.
 Carposporeæ, 257.
 Caryophyllaceæ, 10*f*.
 Caryophyllales, 80*n*.
 Caryopsis, 60.
 Casuarinaceæ, 172.
 Catkin, 38.
 Caudex, 9.
 Caudicle, 51.
 Caulome, 2.
 Celastrales, 80*q*.
 Chalaza, 55.
 Characeæ, 263.
 Chenopodiaceæ, 180.
 Chenopodiales, 86.
 Cicatrix, 21.
 Circumite, 17.
 Cladodes, 9.
 Claw, 45.
 Climbing Stems, 11.
 Cocci, 60.
 Cohesion, 37.
 Coleochaetæ, 266.
 Columella, 248.
 Combretaceæ, 133.
 Commelinaceæ, 204.
 Compositæ, 143.
 Conduplicate, 16.
 Cone, 38.
 Coniferae, 222.
 Conjugatæ, 269.
 Connective, 48.
 Convolvulaceæ, 158.
 Convolute, 17.
 Corm, 7.
 Cormophyta, 2.
 Corolla, 44.
 Corollifloral, 37.
 Corona, 45.
 Coronariceæ, 188.
 Corpuscular, 228.
 Corymb, 38.
 Cotyledons, 18.
 Covering leaves, 19.
 Crassulaceæ, 126.
 Cremocarp, 60.
 Crenate, 26.
 Cruciferae, 96.
 Cryptogamia, 225.
 Cucurbitaceæ, 134.
 Cupule, 61.
 Cyanophyceæ, 270.
 Cyatheaceæ, 238.
 Cycadeæ, 223.
 Cycle, 20.
 Cymose, 14.
 Cyperaceæ, 213.
 Cypselæ, 61.
 Daphnales, 86.
 Darwin's classification of climbing stems, 12.
 Daucus carota, 5.
 Decandria, 80*b*.
 Deciduous, 42.
 Decom-pound, 30.
 Decurrent, 22.
 Decussate, 20.
 Dehiscent fruits, 58.
 Dentate, 26.
 Dextrorse, 11.
 Diadelphía, 80*b*.
 Diadelphous, 49.
 Diandria, 80*a*.
 Dichasium, 14.
 Dichotomeæ, 234.
 Dichotomous, 14.
 Dictamydeons, 34.
 Diclinous, 35. [80*k*.
 Dicotyledonous cohorts (abstract of),
 Dicotyledonous orders (abstract of), 80*k*. [87.
 Dicotyledonous orders (details of),
 Dicotyledons, 80*k*.
 Didynamia, 80*b*.
 Didynamous, 48.
 Differentiation, 2.
 Digitate, 28.
 Dilleniaceæ, 88.
 Diœcia, 80*c*.

- Diœcions, 35.
 Dioscorideæ, 198.
 Dipterocarpeæ, 104.
 Discifloræ, 80*p*.
 Discomycetes, 277.
 Dodecandria, 80*b*.
 Drupe, 60.
 Ebenaceæ, 147.
 Ebenales, 80*x*.
 Elæagnaceæ, 175.
 Emarginate, 26.
 Embricate, 16.
 Embryo-sac, 55.
 Endocarp, 56.
 Endosperm, 69.
 Enneandria, 80*b*.
 Epiphytic roots, 6.
 Epicarp 56.
 Epigynæ, 187.
 Epigynous, 49.
 Equisetaceæ, 234-241.
 Equitant, 16.
 Ericales, 80*w*.
 Erysiphææ, 277.
 Encyclic, 37.
 Euphorbiaceæ, 171.
 Euphorbiales, 84.
 Extrorse, 51.
 Families, 79.
 Fibrous root, 5.
 Ficoidales, 80*w*.
 Ficus Indica, 6.
 Filament, 48.
 Filices, 230.
 Filicineæ, 229.
 Filiform, 48.
 Floats, 32.
 Floral diagram of a typical monocotyledon, 186.
 Floral diagram (The), 76.
 Floral leaves, 19.
 Florets, 39.
 Florideæ, 265.
 Flower of a grass (diagram of), 215.
 Flower of an orchid (diagram of), 194.
 Flower (The), 34.
 Foliage leaves, 18,
 Follicle, 53. [50.
 Forms of andrœcium (abstract of,
 Forms of calyx (abstract of, 43.
 Forms of corolla (abstract of), 46.
 Forms of Foliage leaves, 23.
 Forms of Foliage leaves (abstract of), 31.
 Forms of gynœcium (abstract of, 53.
 Forms of inflorescence (abstract of), 40.
 Forms of Perianth (abstract of), 47.
 Forms of stems (abstract of), 13.
 Fruit (The), 56.
 Fruits classification of (abstract of), 65, 67.
 Fruits (eatable portion of), 68.
 Fucaceæ, 266.
 Fumariaceæ, 96.
 Fungi, 271.
 Funiculus, 54, 68.
 Fusiform root, 4,
 Galbulus, 64.
 Gamopetalæ, 80*v*.
 Gamophyllons, 47.
 Gamosepalous, 42.
 Gasteromycetes, 275.
 Gemmæ, 15.
 Gentianaceæ, 154.
 Gentianales, 80*x*.
 Genus, 78.
 Geraneaceæ, 109.
 Geraniales, 80*p*.
 Gibons, 42.
 Glabrous, 33.
 Glandular hairs, 33.
 Glans, 61.
 Gleicheniaceæ, 239.
 Globule, 264.
 Glomales, 190.
 Glumes, 19.
 Guetaceæ, 221.
 Gonidia, 277.
 Gramineæ, 214.
 Guttiferæ, 103.
 Guttiferales, 80*o*.
 Gymnosperma, 221.
 Gymnospermia, 80*g*.
 Gynœcium, (The), 51.
 Gynandria, 80*c*.

Gynandrophore, 36.
 Gynandrous, 49.
 Gynobasic, 52.
 Gynophore, 36.

Hairs, 2, 33.
 Heptandria, 80*b*.
 Hermaphrodite, 35.
 Heterophyllous, 30.
 Hexandria, 80*b*.
 Hilum, 68.
 Hispid, 33.
 Hooks, 11.
 Hydrocharideæ, 190.
 Hymenium, 272.
 Hymenomyces, 273.
 Hymenophyllaceæ, 239.
 Hypericaceæ, 103.
 Hyphæ, 271.
 Hypocrateriform, 45.
 Hypogynous, 49.

Icosandria, 80*b*.
 Impari-pinnate, 29.
 Incomplete, 83.
 Inflorescence, 37.
 Infundibuliform, 42.
 Insertion, 21.
 Internodes, 15.
 Introrse, 51.
 Involucre, 39.
 Involute, 16.
 Isæteæ, 243.
 Isomerous, 37.
 Isostemonous, 37.

Juga, 29.
 Juncaceæ, 204.
 Jungermannicæ, 254.

Labellum, 47.
 Labiatæ, 160.
 Lamiales, 82.
 Lamina, 21.
 Lauraceæ, 177.
 Laurales, 86.
 Leaflet, 23.
 Leaves, 18.
 Leaves (abstract of), 19.
 Legume, 58.

Leguminosæ, 121.
 Lemna, 3.
 Lichens, 277, 278.
 Ligulatæ, 234.
 Ligulate, 45.
 Ligule, 22.
 Liliaceæ, 200.
 Linaceæ, 111.
 Linnean classes, 80*a*.
 Lobed, 27.
 Loculicidal, 59.
 Lodicule, 47.
 Loganiaceæ, 153.
 Loranthaceæ, 168.
 Loranthus, 6.
 Lycopodiaceæ, 235.
 Lycopodiæ, 243.
 Lythraceæ, 129.

Macrospore, 227.
 Magnoliaceæ, 89.
 Malpighiaceæ, 112.
 Malvaceæ, 105.
 Malvales, 80*a*.
 Marattiaceæ, 236.
 Marcescent, 43.
 Marchantieæ, 254.
 Margin of leaf, 26.
 Marsiliaceæ, 239.
 Medullary rays, 80*i*.
 Melastomaceæ, 128.
 Meliaceæ, 115.
 Member, 2.
 Menispermaceæ, 91.
 Mesocarp, 56.
 Metamorphosed leaves, 2.
 Micropyle, 55.
 Microspores, 227.
 Mid-rib, 18.
 Mimoseæ, 124. [15.
 Modes of branching (abstract of),
 Monacia, 80*c*.
 Monadelphica, 80*b*.
 Monadelphous, 49.
 Monandria, 80*a*.
 Monocarpellary, 52.
 Monoclamydeous, 34.
 Monocleæ, 254.
 Monocotyledons, 183. - [of], 187.
 Monocotyledonous orders (abstract

- Monocotyledonous orders (details of), 190.
- Monœcious, 35.
- Monopodial, 14.
- Moringaceæ, 100.
- Mucronate, 26.
- Mucule, 264.
- Musci, 247.
- Musciacæ, 244.
- Myristicaceæ, 177.
- Myrsinaceæ, 147.
- Myrtaceæ, 127.
- Myrtales, 80s.
- Myxomycetes, 283.
- Naiadaceæ, 211.
- Napiform root, 5.
- Natural system. The, 80g.
- Nelumbiaceæ, 94.
- Nepenthes, 32.
- Nucleus, 55.
- Nudifloræ, 189.
- Nutrition, 1.
- Nyctaginaceæ, 181.
- Nymphæaceæ, 93.
- Obdolute, 16.
- Ochrea, 22.
- Octandria, 80b.
- Edogoniæ, 267.
- Oleaceæ, 149.
- Onagraceæ, 131.
- Oogonium, 226.
- Oosphere, 228.
- Oosporeæ, 238.
- Ophioglossaceæ, 235.
- Opuntia, 9.
- Orchideæ, 194 [250.
- Orders of Hepaticæ (abstract of).
- Orders of Muscinæ (abstract of), 246.
- Orders of Muscinæ (details of), 251.
- Orders of Thallophyta (abstract of), 256, 257.
- Organ, 2.
- Orobanchaceæ, 164.
- Orthotropous, 55.
- Osmundaceæ, 238.
- Ovary, 52.
- Oxalidaceæ, 112.
- Paleæ, 19.
- Palmatifid, 27.
- Palmatipartite, 26.
- Palmatisect, 26.
- Palmeæ, 205.
- Pandanaceæ, 207.
- Panicle, 38.
- Papaveraceæ, 95.
- Papayaceæ, 137.
- Papilionaceæ, 122.
- Papilionaceous, 45.
- Pappus, 43.
- Parasitic roots, 6.
- Parietales, 80m.
- Pari-pinnate, 29.
- Passifloraceæ, 134.
- Passiflorales, 80t.
- Pedate, 28.
- Pedicel, 37.
- Peduncle, 36, 37.
- Peltate, 25.
- Peltate hairs, 33.
- Pentandria, 80a.
- Pepo, 62.
- Perianth, 34.
- Perianth (The), 47.
- Pericarp, 56.
- Perichætinum, 245.
- Perigynous, 49.
- Perisperm, 69.
- Peristome, 251.
- Personales, 82.
- Personate, 45.
- Petals, 44.
- Petiole, 21.
- Phasaceæ, 253.
- Phycomycetes, 281.
- Phyllome, 2, 18.
- Phyllotaxis, 20.
- Pileus, 273.
- Pinnate, 28.
- Pinnatifid, 27.
- Pinnatipartite, 26.
- Pinnatisect, 26.
- Piperaceæ, 170.
- Piperales, 84.
- Pista, 6.
- Pistiaceæ, 210.
- Pistil, 51.
- Pistillate, 35.

Pitcher plant, 32.
 Pith, 80*i*.
 Placenta, 54.
 Plant (definition), 1.
 Plants (description of), 71.
 Plasmodium, 283.
 Plicate, 17.
 Plumbaginaceæ, 145.
 Polemoniaceæ, 157.
 Polemoniales, 81.
 Pollen grains, 50.
 Pollen sacs, 50.
 Pollinia, 51.
 Polyadelphia, 80*c*.
 Polyadelphous, 49.
 Polyandria, 80*b*.
 Polycarpellary, 52.
 Polygalaceæ, 100.
 Polygalales, 80*u*.
 Polygamia aequalis, 80*c*.
 " frustranea, 80*c*.
 " necessaria, 80*c*.
 " Segregata, 80*c*.
 Polygamia superflua, 80*c*.
 Polygamous, 36.
 Polygonaceæ, 178.
 Polypodiaceæ, 236.
 Pome, 64.
 Pontederiaceæ, 203.
 Porous dehiscence, 51.
 Portulacaceæ, 102.
 Prefloration, 17.
 Prefoliation, 17.
 Prickles, 34.
 Primary-root, 3.
 Primulales, 80*w*.
 Proteaceæ, 176.
 Prothallium, 226.
 Protonema, 244.
 Protophyta, 260.
 Psiloteæ, 244.
 Pubescent, 33.
 Pulvinus, 21.
 Putamen, 57.
 Pyrenomyces, 276.
 Pyxidium, 58.

Raceme, 38.
 Racemose, 14.
 Rachis, 37.
 Ranales, 80*l*.
 Ranunculaceæ, 87.
 Raphe, 55.
 Repand, 26.
 Resedaceæ, 98.
 Retinaculum, 51.
 Revolute, 16.
 Rhamnaceæ, 116.
 Rhizocarpeæ, 233.
 Rhizomes, 7.
 Rhizophoraceæ, 132.
 Ricciæ, 254.
 Root, 3.
 Root abstract of forms of, 5.
 " 7.
 Root-cap, 2.
 Rosaceæ, 125.
 Rosales, 80*r*.
 Rubiaceæ, 141.
 Rubiales, 80*v*.
 Runners, 9.
 Saccharomyces, 283.
 Salviniaceæ, 240.
 Samara, 61.
 Santalaceæ, 169.
 Santalales, 83.
 Sapindaceæ, 117.
 Sapindales, 80*r*.
 Sapotaceæ, 148.
 Sarcocarp, 57.
 Scapæ, 37.
 Schedules (Professor Henslow's) 73.
 Schizæaceæ, 238.
 Schizocarp, 58.
 Schizomycetes, 284.
 Scitamineæ, 193.
 Scorpioid cyme, 39.
 Scrophulariaceæ, 163.
 Secondary root, 3.
 Selaginellæ, 242.
 Septicidal, 59.
 Septifragal, 59.
 Serrate, 26.
 Seta, 245.
 Sexual system, 80.
 Siliqua, 58.

Quernales, 84.
 Quincuncial, 16.

Siphonææ, 268.
 Sinistorse, 11.
 Smilacææ, 203.
 Solanacææ, 155.
 Sorosis, 64.
 Spadix, 38.
 Spathe, 19, 38.
 Species, 77.
 Spermatozoid, 226.
 Sphagnacææ, 253.
 Spike, 38.
 Spines, 34.
 Spores, 226.
 Square stems, 9.
 Stamen, 48.
 Staminate, 35.
 Stem, 7.
 Sterculiacææ, 106.
 Stigma, 52.
 Sting, 34.
 Stipitate, 36.
 Stipulatææ, 230.
 Stipules, 22.
 Stolon, 9.
 Strobilus, 64.
 Style, 52.
 Syconous, 64.
 Styracææ, 148.
 Sympode, 14.
 Syncarpous, 53.
 Syngenesia, 80c.
 Syngenesions, 49.
 Synsepalous, 42.
 Tamaricacææ, 102.
 Tap root, 4.
 Tegmen, 55.
 Tendrils, 11, 32.
 Terminal bud, 15.
 Ternstroemiacææ, 104.
 Testa, 55.
 Tetradyamia, 80b.
 Tetradyamous, 48.
 Tetrandia, 80a.
 Tetraspore, 265.
 Texture of leaves, 32.
 Thalamiflorææ, 80l.
 Thalamifloral, 37.
 Thalamus, 36.
 Thallophyta, 2, 255.

Theca, 245.
 Tiliacææ, 107.
 Torus, 36.
 Tremellinææ, 273.
 Triadelphous, 49.
 Triandria, 80a.
 Trichogyne, 265.
 Trichomes, 2.
 Trichophore, 265.
 Tri-pinnate, 30.
 Truncate, 26.
 Trunk, 8.
 Tuberacææ, 276.
 Tuberous root, 5.
 Tubers, 8.
 Tubular, 42.
 Twining stems, 11.
 Typhacææ, 209.
 Umbellales, 80u.
 Umbelliferææ, 140.
 Urticacææ, 173.
 Urticales, 85.
 Utriculariacææ, 164.
 Vaginate, 21.
 Valvate, 16.
 Vanda Roxburghii, 6.
 Variety, 77.
 Vascular cryptogams, 226.
 Vascular cryptogamic orders (abstract of), 229.
 Vascular cryptogamic orders (details of), 235.
 Verbenacææ, 162.
 Vernation, 16.
 Verticel, 20.
 Vexillary, 16.
 Vexillum, 45.
 Villous, 33.
 Violacææ, 99.
 Vitacææ, 116.
 Volvocinææ, 269.
 Whorl, 20.
 Zygomycetes, 282.
 Zygophyllacææ, 113.
 Zygosporææ, 259.



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